Idaho Waste Management Guidelines For Confined Feeding Operations

Prepared by

Jack Palmer, P.E.

Water Quality Agricultural Engineer (IPA)

Idaho Department of Health and Welfare

Division of Environmental Quality

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Abstract

Methods of managing animal waste on confined feeding operations (CFO)--dairies, feedlots, sheep, hogs, poultry, and other animal-rearing facilities directly affect the potential for pollution of Idaho's surface and ground waters. The purpose of this document is to help confined feeding operation managers and regulators understand management practices and design criteria that prevent water pollution. This information can be used to develop best management practices (BMPs).

These guidelines also are intended to assist managers in complying with state and federal water quality regulations and clarify governmental agency involvement.

The introduction sets the context for specific guidance in Chapters 3 through 12. Information on water quality, existing regulations, site evaluation, and planning considerations should improve evaluation of a confined feeding operation. It also will provide general direction for developing a waste management system best management practice to comply with the legal requirements.

The intent of these guidelines is to show that waste and wastewater must be captured, treated, and stored on site for proper treatment, preferably through agronomic utilization back on the land. The basic methods to achieve a good waste management system are explained in the text. The topic of Chapter 6, minimizing wastewater volumes by conserving water and diverting surface runoff, is often overlooked as a means of reducing size of storage basins or preventing overflows in existing basins. Management of precipitation runoff for the surface of the lot is discussed in Chapter 7. Chapter 8 outlines the critical design criteria for waste collection and storage facilities. Chapter 9 explains estimating storage requirements in a step-by-step procedure.

Land application of animal waste may be a source of non-point source pollution, particularly ground water. To prevent this, it must be managed properly as described in Chapter 10. Practices that help control odors and other potential pollutants are described in Chapters 10 and 11.

Chapter 1 Introduction

Due to increasing development and use of land and water resources, responsible land stewardship is critical. Use of streams, canals, rivers, and lakes to dispose of waste from confined feeding operations, or allowing wastes to reach ground water, is no longer acceptable.

A practice that manages wastes on confinement areas and on cropland where wastes are fully utilized, to maintain surface and ground water quality at desired levels, is a best management practice (BMP). A BMP is the most effective way to prevent or reduce pollution generated from confined feeding operations. Because of unique site characteristics, water quality goals, practices and operation management, a BMP will be unique for each site.

These guidelines are meant to help managers evaluate specific situations and understand practices needed to implement a BMP. The 1991 Idaho Agricultural Pollution Abatement Plan (Ag Plan) states, "Using the Idaho Waste Management Guidelines for Confined Feeding Operations with site-specific information will result in a Best Management Practice designed to meet water quality goals." The plan addresses Idaho's agricultural nonpoint source water quality concerns in response to the federal Clean Water Act. Conservation, environmental, and industry groups assisted technical agencies in developing these guidelines.

The Ground Water Protection Plan adopted by the 1992 Legislature establishes criteria to protect ground water quality. The Idaho Ground Water Vulnerability Mapping Program and the Environmental Protection Agency's Sole Source Aquifer designations have been established to provide adequate protection of particularly susceptible state waters. In these areas, additional requirements may be necessary to safeguard ground water quality.

Various federal, state, and local agencies ensure proper waste management of confined feeding operations. They are responsible for programs including the Idaho Agricultural Pollution Abatement Plan (Ag Plan).

Division of Environmental Quality (DEQ)

The DEQ is responsible for protecting surface and ground water quality in Idaho. It is concerned with wastes and other pollutants entering and adversely impacting state water quality. It will provide information to confined feeding operation managers to assist them in proper waste management.

U.S. Environmental Protection Agency (EPA)

The EPA regulates discharge of pollutants to waters of the United States under authority of the Idaho General NPDES CAFO (National Pollutant Discharge Elimination System Concentrated Animal Feeding Operation) Permit. Discharge of pollutants to waters of the United States from CAFOS, except as provided in the permit, is a violation of the Clean Water Act (CWA), subject to penalty.

Proper waste management greatly reduces the probability of discharge and reduces the possibility of penalty.

Idaho State Department of Agriculture (ISDA)

The ISDA is responsible for administering the Idaho manufactured Grade and Grade A Dairy Program. ISDA is concerned with improperly managed wastes and other pollutants affecting sanitation of dairy products and is responsible for the approval and operation of dairy waste systems as outlined in Title 37-Chapter 4 Idaho Code and rules found in IDAPA 02.04.14.

Idaho Department of Water Resources (IDWR)

The IDWR regulates water appropriation and well construction.

Food and Drug Administration (FDA)

The FDA is concerned with sanitation of milk production.

USDA Agencies

Natural Resources Conservation Service (NRCS): The NRCS provides technical and financial assistance for developing BMPs and design of waste management facilities.

Cooperative Extension System (CES): The CES provides educational programs in constructing, operating, and maintaining confined feeding operations waste management systems. They can also assist in the siting, design and sizing of waste management systems for livestock facilities.

Local Agencies

Soil Conservation District (SCD): The SCD is the local management agency responsible for agricultural non-point source pollution activities. It provides assistance to private landowners through design or adoption of BMPs and component practices to meet State Water Quality Standards and protect beneficial uses.

Irrigation Districts: Local irrigation districts are responsible for water conveyance for irrigation purposes. They are concerned with wastes and debris entering canal and drain systems.

County Planning and Zoning: Certain counties have local laws or regulations concerning confined feeding operations. Other counties may develop such regulations.

Animal Waste Management Concerns

A confined feeding operation is a contiguous area or parcel of land where there are confined livestock including fowl, furbearers, cattle, dairy animals, swine, sheep, goats, horses, llamas, mules, donkeys, and similar domesticated animals, including their offspring.

Livestock confinement is defined as the keeping of animals within a structure or area for a period of more than 48 hours during any seven consecutive days, except where such livestock are fed exclusively on growing range, pasturage or crop residues, or are confined on cropland of 20 acres or more for a period of not more than 120 days in any calendar year.

In 1997 there were 1050 dairies and 270,000 mature dairy cows in Idaho. These operations are primarily on the Snake River Plain (APAP 1991). It is estimated that dairy cattle produce 85 pounds of manure per day per 1,000 pounds of live weight. In one year, a 500-cowherd of 1,000-pound cows can produce about 7,750 tons of manure containing 850 tons of solids with 34 tons of nitrogen, six tons of phosphorous, and 25 tons of potassium (USDA-SCS, 1992).

In 1996, there were 45 feedlots in Idaho with 617,000 head of cattle (Idaho Agricultural Statistics). Feedlot cattle produce an estimated 62 pounds of manure per day per 1,000 pounds of live weight. A 500-head lot can produce about 6,900 tons of manure per year with 810 tons of solids, 39 tons of nitrogen, eight tons of phosphorous, and 21 tons of potassium (USDA-SCS, 1992).

In 1995, there were about 16,000 head of sheep and lambs, 45,000 hogs and pigs on feed, and a few large commercial poultry operations with a total of approximately 1,000,000 birds in Idaho. Approximate animal numbers for other animal-rearing operations are not known.

Estimated total yearly production of manure, solids, nitrogen, phosphorus and potassium are shown below. Amounts shown are those excreted by the animals (USDA-SCS, 1992). The actual amount of nutrients available for application is dependent upon several factors, including animal and ration, and manure storage, handling and treatment conditions.

Livestock Type	Animal Number	Manure Tons/yr	Solids Tons/yr	Nitrogen Tons/yr	Phosphorus Tons/yr	Potassium Tons/yr
Dairy	270,000	5,863,800	641,600	25,500	4,800	13,800
Feedlot	617,000	6,981,400	1,002,200	48,400	10,100	25,900
Swine	45,000	113,300	11,800	700	300	400
Sheep	16,000	18,400	4,900	200	38	200
Poultry	1,000,000	38,700	10,100	600	300	300

Table 1. Idaho Livestock Statistics

Animal waste contains elements which may impact surface and ground water quality. The most common potential pollutants are suspended solids, organic wastes, bacteria, and nutrients (nitrogen and phosphorus compounds). Other potential pollutants associated with confined feeding operations include petroleum products and pesticides.

The major effect of poor waste management is degradation of water quality. Principal problems that may be associated with discharges from poorly-operated confined feeding operations are:

- Organic materials such as manure decrease dissolved oxygen concentration which may adversely affect fish and other aquatic organisms;
- Settling of solids in streambeds may destroy spawning areas and fish food organisms;
- Bacterial and viral concentrations increase the potential spread of disease. Organisms such as Vibrio, Rotavirus, Leptospirosis, Salmonella, and others are spread by animal waste discharges;
- Nitrogen compounds kill aquatic organisms by ammonia toxicity;
- Infiltration of nitrates into ground water occurs from improperly sealed storage ponds or corrals where soils are highly permeable or where fractured bedrock is close to the surface. High nitrates in surface and ground water pose a health hazard for humans and animals;
- Improper use of pesticide compounds in confined feeding operations increases the potential of these chemicals to impact surface and ground water. Pesticides in surface or ground water pose a hazard for humans and the environment;
- Discharges to irrigation canals may clog canals, laterals, and intake pipes and will increase moss and aquatic plant growth. This could decrease flow efficiency, raise canal maintenance costs, and increase the potential to impact water quality, if chemicals are used to control plant growth;
- Animal wastes applied to the land in amounts that exceed nutrient requirements of crop and soil capacity or applied at the wrong time may impact surface or ground water quality;
- Nuisance conditions such as odor, rodents, and fly problems may occur;
- High animal concentrations and or operations in an area may have a higher potential to impact water quality when they are improperly managed.

Objectives of Animal Waste Management

The primary objectives of animal waste management are:

- To prevent water pollution and maintain or improve Idaho’s water resources;
- To collect and store all solid and liquid waste on-site in a manner that prevents wastes from entering surface water and seepage of nutrients into ground water;
- To manage both solid and liquid waste, preferably by proper land application for crop production and soil enhancement without excessively loading the soil profile which could result in ground water pollution;
- To control odors, flies, rodents, and other vermin;
- To install a system that will solve present problems and prevent future animal waste problems economically;
- To use and store pesticides in such a manner as not to adversely affect water quality or the environment.

Purpose of Guidelines

The purpose of these guidelines is:

- To describe basic waste management practices;
- To educate owners and operators to effectively manage waste systems to protect Idaho's surface and ground water;
- To identify alternative practices that meet primary objectives of an animal waste management system that, when applied in combination, will result in a BMP.
- To establish criteria and practices to prevent non-compliance and discharge violations.

Not all of these guidelines may be needed for a confined feeding operation, only those that are appropriate to the particular site. Also, some practices may not be practical. Therefore, innovative, site-specific solutions to an animal waste management problem are encouraged.

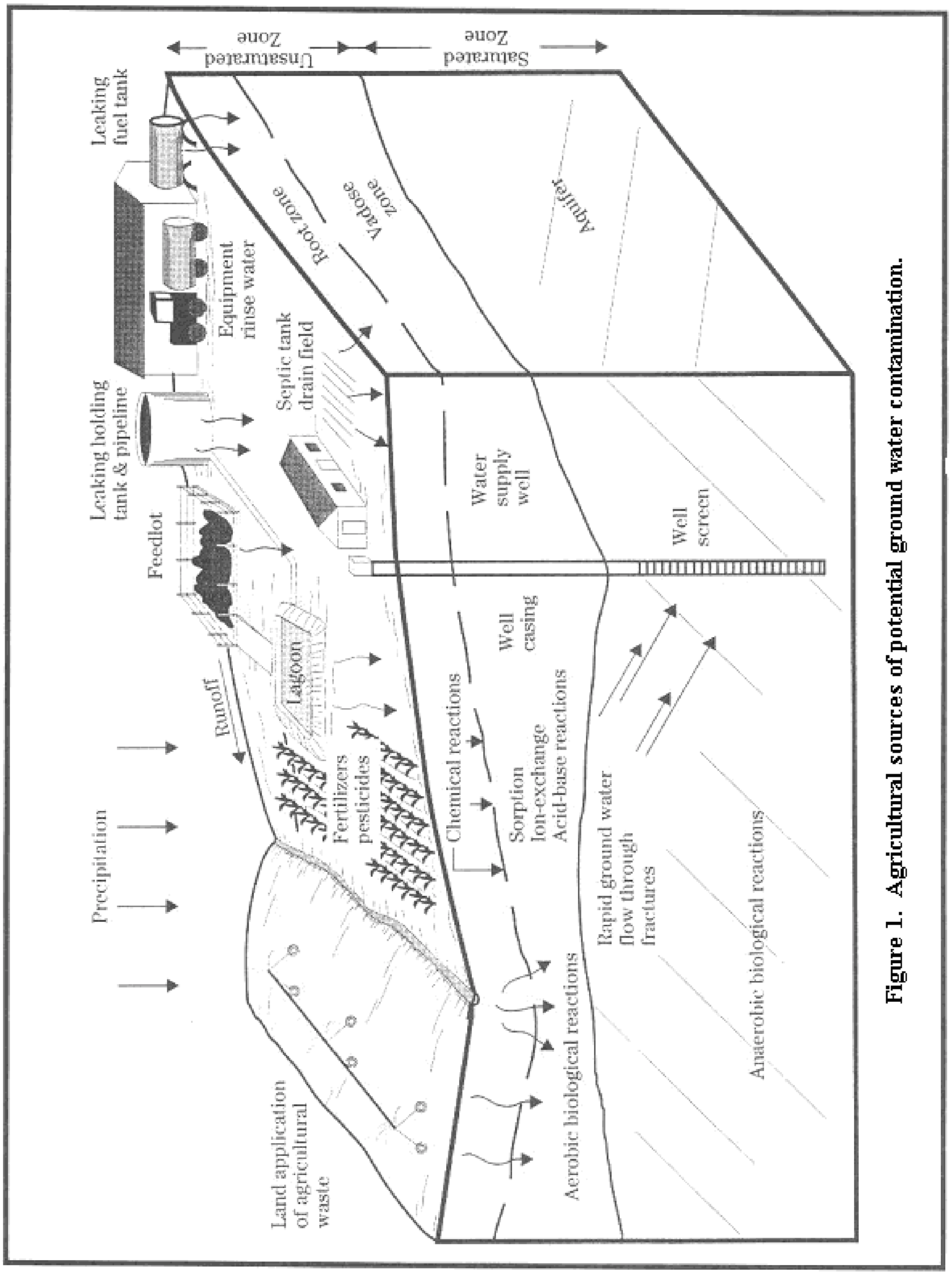
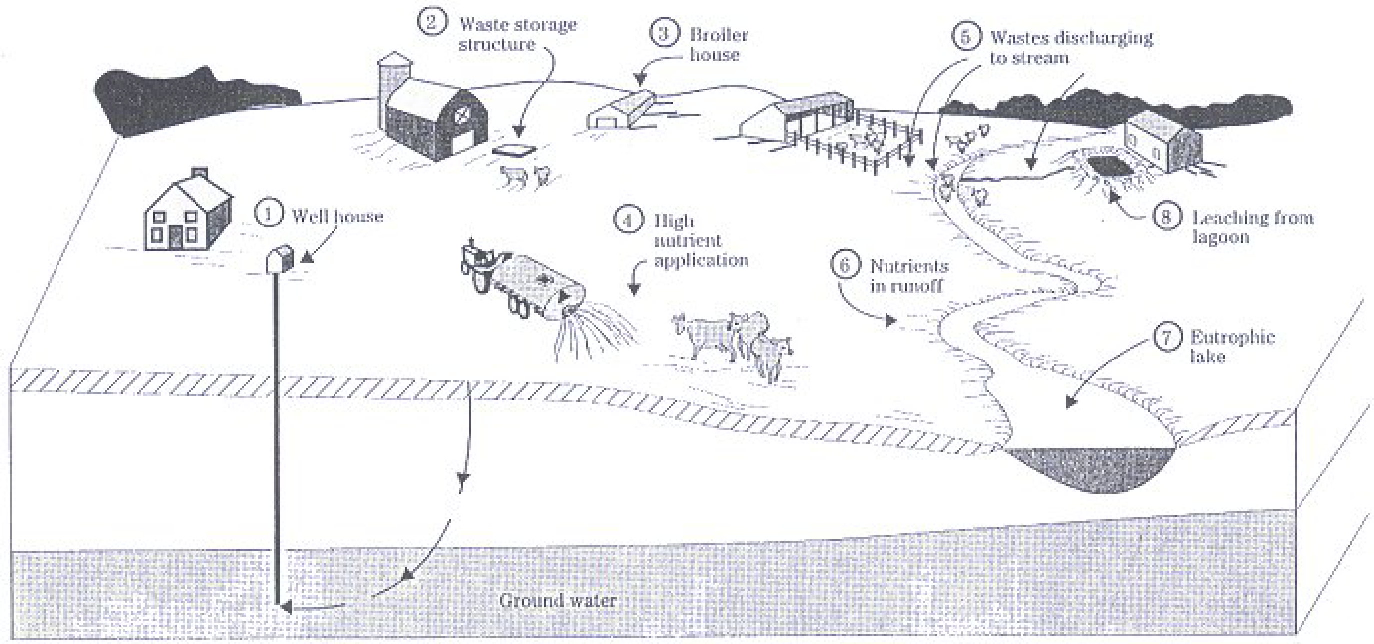


Figure 1. Agricultural sources of potential ground water contamination.



1. Contaminated well: Well water contaminated by bacteria and nitrates because of leaching through soil.
2. Waste storage structure: Poisonous and explosive gases in structure.
3. Animals in poorly ventilated building: Ammonia and other gases create respiratory and eye problems in animals and corrosion of metals in building.
4. Waste applied at high rates: Nitrate toxicity and other N-related diseases in cattle grazing cool-season grasses; leaching of NO_3 and microorganisms through soil, fractured rock, and sinkholes.
5. Discharging lagoon, runoff from open feedlot, and cattle in creek: (a) Organic matter creates low dissolved oxygen levels in stream; (b) Ammonia concentration reaches toxic limits for fish; and (c) Stream is enriched with nutrients, creating eutrophic conditions in downstream lake.
6. Runoff from fields where livestock waste is spread and no conservation practices on land: P and NH_4 attached to eroded soil particles and soluble nutrients reach stream, creating eutrophic conditions in downstream lake.
7. Eutrophic conditions: Excess algae and aquatic weeds created by contributions from items 5 and 6; nitrite poisoning (brown-blood disease) in fish because of high N levels in bottom muds when spring overturn occurs.
8. Leaching of nutrients and bacteria from poorly-sealed lagoon: May contaminate ground water or enter stream as interflow.

Figure 1a. Possible danger points in the environment from animal waste.

Chapter 2 Current Regulations

Idaho Water Quality Standards

The Idaho Water Quality Standards and Wastewater Treatment Requirements, Title 1, Chapter 2, regulate confined feeding operations as they apply to waste management and protection of beneficial uses of state waters. The Idaho Water Quality Standards are administered by the Idaho Division of Environmental Quality.

Specific regulations that apply are:
Section 01 .02.001 Legal Authority

Section 01.02.002 Title and Scope

Section 01.02.003 Definitions
- -.04 Appropriate Beneficial Use
- -.09 Best Management Practice
- -.51 Land Application
- -.62 Nonpoint Source Activities
- -.76 Point Source
- -.77 Pollutant
- -.80 Project Plans
- -.91 Sewage
- -.94 Sludge
- -.103 Total Maximum Daily Load (TMDL)
- -.106 Treatment
- -.107 Treatment System
- -.112 Waste Water
- -.113 Water Pollution
- -.116 Waters and Waters of the State

Section 01.02.054 Water Quality Limited Waters and TMDLs

Section 01.02.070 Application of Standards

Section 01.02.080 Violations of Water Quality Standards

Section 01.02.100 Surface Water Use Classification

Section 01.02.101 Use Designations for Surface Waters

Section 01.02.350 Rules Governing Nonpoint Source Activities

Section 01.02.400 Rules Governing Point Source Discharges

Section 01.02.401 Point Source Wastewater Treatment Requirements

Section 01.02.402 Reviews of Plans for Waste Treatment Facilities

Section 01.02.420 Point Source Sewage Wastewater Discharge Restrictions

Section 01.02.600 Land Application of Wastewater or Recharge Water

Section 01.02.650 Sludge Usage

Section 01.02.800 Hazardous and Deleterious Material Storage

Requirements of these rules are:

- Restrictions are placed on discharge of wastewaters and human activities which may adversely affect water quality in Idaho;

- State waters are protected for beneficial uses for which they are suitable, including agricultural and domestic water supplies, and support for aquatic organisms and recreation. Surface waters have classifications with specific limits for parameters such as bacteria, dissolved oxygen, ammonia, and temperature.

- Construction of waste treatment and disposal facilities must submit to pre-construction plan review and approval for new or modified waste systems. These plans need to be submitted to the appropriate state regulatory agency and local planning and zoning commissions, if appropriate.

- Hazardous and deleterious materials must not be stored in such a manner to enter or have the potential to enter state waters. Such materials include, but are not limited to, trash, rubbish, garbage, oil, gasoline, chemicals, sawdust, and accumulations of manure.

The Idaho Ground Water Quality Rule, IDAPA 16, Title 1, Chapter 11 regulates confined feeding operations and land treatment of solid and liquid dairy waste as it relates to protection of existing and future beneficial uses of ground water in the state. The Ground Water Quality Rule is administered by the Idaho Division of Environmental Quality.

Specific sections of the Rule that apply are:

Section 01.11.000 Legal Authority

Section 01.11.001 Title and Scope

Section 01.11.007 Definitions

-.01 Agricultural Chemical
-.02 Aquifer
-.03 Beneficial Uses
-.08 Cleanup
-.10 Contaminant
-.16 Ground Water Quality Standard
-.19 Natural Background Level
-.26 Site Background Level

Section 01.11.200 Ground Water Quality Standards

Section 01.11.301 Management of Activities With the Potential to Degrade Aquifers

Section 01.11.400 Ground Water Contamination

Requirements of these rules are:

- Minimum requirements are established for protection of ground water quality through standards and an aquifer categorization process. If a natural background level exceeds a standard, that natural level becomes the standard;

- Ground water is not to be degraded and standards are not to be exceeded unless allowed by DEQ under certain circumstances.

Rules Governing Grade A Pasteurized Milk

The 1993 Grade A Pasteurized Milk Ordinance (PMO) was adopted by reference as rule under IDAPA 02.04.08. The Grade A Pasteurized Milk Ordinance regulates confined feeding operations as it applies to waste management and sanitation of Grade A dairy products. The Idaho Grade A Dairy Program is administered by the Idaho State Department of Agriculture.

Specific sections of the PMO that apply are:

- Part II – Section 5 Inspection of Dairy Farms
- Part II – Section 7 Cow Yard
- Part II – Section 7 Milkhouse or Room, Construction and Facilities
- Part II – Section 7 Toilet
- Part II – Section 7 Water Supply
- Part II – Section 12 Future Dairy Farms and Milk Plants
- Appendix C Construction Standards for Toilet and Sewage Disposal Facilities
- Appendix D Standards for Water Sources

Requirements of these rules are:

- Cow yards must be graded and drained with no standing pooled water or accumulated organic wastes. If manure is used for bedding, straw or other materials must be added to prevent soiling the cows udders and flanks;
- All waste discharges must be properly disposed;
- Toilet facilities must be conveniently located. If water under pressure is available, a flush toilet must be provided and connected to a septic tank and drain field approved by the appropriate state agency. If a city sanitary sewer line is available, it should be utilized. Floor drains must be trapped and maintained, if connected to a sewer system;
- Water wells must be constructed and operated in accordance with the State Health Authority. Water used in the milking operation and cooling of milk must be from a safe source and properly protected. This water must meet appropriate state agency bacteriological standards. There can be no connection between safe and unsafe water supplies and no improper submerged inlets can exist unless an approved backflow prevention device is utilized to protect the water supply;
- Dairy surroundings must be neat and clean and free of harborages and breeding areas for insects or rodents. Proper manure disposal methods should be used to

minimize fly breeding. Spilled or improperly handled milk and garbage should be discarded properly;

- All new dairies or reconstructed or extensively altered dairies regulated under Grade "A" rules must submit plans for milking parlors and milk plants for the purpose of milk production to the Idaho State Department of Agriculture for written approval.

Idaho Dairy Laws

Idaho Dairy Laws, Title 37, Chapter 4, regulate confined feeding operations as they apply to waste management and sanitation of manufactured Grade and Grade A dairy products. The Idaho manufactured Grade and Grade A Dairy Program is administered by the Idaho State Department of Agriculture.

Specific applicable regulation is:

- Section 401 Inspections by Department and Director

Requirements of this regulation are:

- Cow yards, loafing areas, manure lagoons, and similar areas must be maintained to prevent conditions which may affect milk quality;
- Adequate sanitation of containers, equipment, buildings, premises, or anything employed in the production, handling, storing, processing, or manufacturing of dairy products;
- Review plans and specifications for construction and operation of dairy waste systems;
- Penalties for violations.

Water Appropriation

Chapter 2, Title 52 of the Idaho Code provides statutory guidelines for the appropriation of water with the state. The Idaho Water Appropriation Rules and Regulations augment these statutes. In general, a water right must be obtained for a dairy operation. An exception is that if the source is ground water and if the total daily requirement is less than 13,000 gallons per day a water right application is not required.

A water right filing must be advertised and is subject to protest. Successful securement of a water right can become a significant effort, so prospective water users are encouraged to contact the IDWR early in the facility planning process.

IDWR maintains regional offices in Boise, Twin Falls, Idaho Falls and Coeur D’Alene to provide assistance to the public for water appropriation and other regulatory programs.

Well Construction Standards

Section 42-238 and 42-238b, Idaho Code, provide statutory guidelines for the regulation of construction of wells within the state. The Idaho Well Construction Standards Rules and Regulations augment these statutes. A well drilling permit must be obtained for any well drilled in the state, and the well must be drilled by a licensed driller in conformance with the statutes, rules and regulations.

If the total daily diversion exceeds 13,000 gallons, a well drilling permit will be issued only after a water right is secured. The well drilling permit will often have specific conditions of approval. Prospective well owners are encouraged to contact the nearest IDWR regional office early in the well planning process.

National Pollution Discharge Elimination System (NPDES Permit)

The National Pollution Discharge Elimination System (NPDES) permit program regulates discharges from Concentrated Animal Feeding Operations (CAFO) under the Clean Water Act (CWA). An NPDES general permit applies the same effluent limitations and requirements to all discharging CAFOs in Idaho. In Idaho, the NPDES permit program is administered by the U.S. Environmental Protection Agency (EPA).

NPDES permit requirements are summarized below, highlighting major requirements of immediate concern to cattle feedlots, dairy operations, or swine operations. They do not represent all conditions of the permit. For more information, call EPA in Seattle at 1-800-424-4EPA.

1. EPA defines a CAFO as a site where a) and b) are true:

a) Pollutants (contaminated runoff, process wastewater, manure) may be discharged into surface water. Examples of typical discharges that are regulated are overflow from a liquid manure storage pond, corral runoff, land application site runoff or direct access of cattle to waterways;

b) Specific numbers of animals confined at least 45 days in any 12-month period, including dairy cattle, poultry, swine, etc.

2. Confined feeding operations (CFO), which do not meet these specifications may be designated as a CAFO by EPA after an inspection reveals that the CFO is a significant contributor of pollution to surface and/or ground water.

3. If you have a permit, it means that a discharge is allowed, under certain precipitation conditions, but only under the following conditions:

a) Collection and/or storage facilities are provided and properly operated and maintained to contain all wastewater (such as milking parlor and washing pen wastewater) and contaminated runoff from a 25-year, 24-hour rainfall event for the site location; and

b) The facility is designed, operated, and maintained to contain all runoff from accumulation of winter precipitation. To determine the amount of accumulated winter precipitation, assume a minimum of three (3) inches of runoff or calculate runoff based on precipitation values for the one in five-year winter (see Table 7). All information supporting retention of less than three inches must be kept on site and made available upon request; and

c) Animals confined in the CAFO are not allowed direct contact with canals, streams, lakes, or other waters of the United States. Fences may be used to restrict access;

4. If you do not have a permit and your operation qualifies as a CAFO as defined above, any discharge occurring from your operation is a violation of the Federal Clean Water Act, and you may be subject to a penalty and/or given a schedule to correct the problem.

5. To be covered by the permit and allowed to discharge as described, you must send a letter to EPA requesting to be covered by the general permit. Please mail the following information to:

NPDES PERMIT
Environmental Protection Agency
1200 6th Avenue
Seattle, Washington 98101

- Previous NPDES permit number, if applicable;

- Owner's name, address, and telephone number;

- Operator's name, address, and telephone number;

- Types of waste handling practices used for processing wastes (such as containment in a waste storage pond plus land application);

- Type and number of animals confined;

- Name of surface waters that might receive a discharge from the facility (including canals, laterals, rivers, etc.);

- A sketch of the operation, including control facilities, diversion ditches, building structures, feeding areas, slope, direction of overland and surface water flow, and proximity to surface waters. Include any other information that would add to EPA's understanding of the operation. The sketch does not need to be professionally drawn; a hand-drawn sketch is acceptable. However, it is important to list dimensions.

In the event of a discharge, you must report the following information to EPA:

- Description, cause, and estimated duration and volume of discharge;
- Period of discharge and, if applicable, how long it is expected to continue, dates, times, and steps taken to correct and prevent another discharge;
- If caused by precipitation event, information concerning amount of precipitation during 24 hours prior to discharge. National Weather Service stations to call for information are:
    - Boise - 334-9860
    - Pocatello - 236-6900

Sole Source Aquifer Project Review

Under Section 1424(e) of the Safe Drinking Water Act (SDWA), proposed livestock and conservation projects that are to receive “federal financial assistance” and which have the potential to contaminate an EPA designated Sole Source Aquifer (SSA) “so as to create a significant hazard to public health” are subject to EPA review and approval. Project proponents are encouraged to work closely with federal funding agencies early in the application process to determine if EPA review is required, what information is necessary for submittal to EPA, and to implement steps to expedite the review process.

For more information on the Region 10 Sole Source Aquifer Protection Program:

Please call Toll-free from AK, ID, OR, and WA at 1-800-424-4EPA

World Wide Web URL
http://www.epa.gov/r10earth/offices/water/ow.htm

Chapter 3 Planning a Waste Management System

A number of factors influence the decision to build a new facility or expand or modify an existing one. Once such a decision is made, operators need to develop a plan to handle all sources of waste from the barn, milking center, corrals, calf pens and so on.

Environmental Factors

Rainfall - How many inches of rain are expected from a 25-year, 24-hour storm? What is the annual average precipitation? What is the average one-in-five-year winter precipitation/snowmelt runoff?

Stream Location - Where are nearby streams and canals located? How will locating facilities or installing berms and ditches minimize potential discharges to a stream or canal?

Temperature - How will winter temperatures affect the operation and ability to land apply solid or liquid wastes?

Topography - How can runoff from sloped terrain be controlled? Is the land too steep for pond construction or land application? Can runoff be diverted to avoid contamination? Can topography be altered to enhance waste control?

Soil Type - What is the permeability where the proposed storage pond is to be built? Are there boulders or bedrock near the surface?

Surface Drainage - How are the necessary runoff storage volumes calculated and which runoff curve number should be used? Are all areas contributing runoff included in calculations?

Water Table Depth - How near the surface is ground water which may limit depth of the storage pond? Does fractured rock allow access to ground water by stored or runoff waste?

Well Location - Are there any irrigation, drinking, or injection wells in the area?

Operational Factors

Herd Size - How much waste will the facility have to handle? Will herd size increase in the near future?

Cropping & Feeding Practices - How can these practices be coordinated with manure and liquid waste application to cropland?

Land Area - Is there enough land to construct an adequate animal waste system (i.e., for ponds and other structures)? Is there enough land to meet planning and zoning requirements?

Availability of Cropland for Liquid and Solid Manure Application - Is there enough cropland to accept all wastes to match nutrients to crop uptake or should arrangements be made with a nearby farmer?

Existing Buildings & Machinery - Which waste transport and storage options would be most efficient and economical based on available machinery and existing structures?

Facilities - What are the sources of waste being stored - parlor, holding pen, feed alleys, housing, and cooling water?

Economic Factors

Availability of Capital & Labor - How much money and labor must be invested to adequately protect surface and ground water? Which system or set of BMPs is best suited for your particular location?

Future Expansion Plans

Facility Design - How can the facility be designed to accommodate an increase in herd size or a change in management over the next few years?

Social Factors

Neighbors - Where are the nearest residences? How can odors and flies be minimized?

Permit Requirements - If Applicable

EPA General Permit - The permit requires sizing a waste facility to prevent discharges and to contain all wastewater and runoff from a 25-year, 24-hour storm event plus snowmelt over drainage area from a one-in-five-year winter. Idaho Code, Section 39-118 requires that plans and specifications for all new or modified waste treatment or disposal facilities be submitted to DEQ for review and approval prior to construction. Title 37 Chapter 4 Idaho Code requires Department of Agriculture, instead of DEQ, approval for dairy waste systems.

Zoning - What are future development plans for the area? Is the land zoned for agriculture only? Are there county building requirements?

Consider the Alternatives

Because of the number of influencing factors, there is no one Best Management Practice that can be recommended to all confined feeding operation managers. A BMP should be specific to the individual operation and based on existing physical, operational, and economic conditions, opportunities and constraints, and whether you are expanding, remodeling, or rebuilding. Consider management options presented in these guidelines, but don't stop there. Other options and further details are available in the list of guidance manuals.

For an existing livestock operation, evaluate existing pollution potential, then consider alternatives and select the most practical methods to effectively manage all waste.

For a new livestock operation, site selection is the most important consideration. Most potential operational and environmental problems can be minimized through careful site evaluation and selection. Obtain information on the soil and topography before buying land. Consider major management options, different kinds of housing, various types of waste handling equipment, and storage alternatives. Zoning ordinances are a very important consideration before deciding to build a CFO. Zoning ordinances can provide protection to the CFO owner as well as rural residences.

In all cases, it is necessary to take into consideration plans for future expansion. Ideally, planning animal waste management systems should be open-ended so a system may be expanded or improved.

Careful planning can minimize problems caused by equipment breakdown, vacations, sickness, adverse weather conditions, and future expansions. Try to avoid special equipment with limited use.

Operating Plan

Developing an animal waste management operating plan is critical to ensure the operation complies with federal, state, and local waste management requirements. At a minimum, the plan should include:

- A description of equipment and structures used to collect, transport, store, and land-apply animal wastes and wastewater, including storage volume and storage time;
- Schedules for emptying storage facilities and land-applying accumulated solids;
- Schedules, rates, and locations for application of waste;
- Maintenance program requirements for handling/storage facilities and application equipment;
- Agreements with other landowners to accept liquid or solid wastes, if necessary.

Getting Help

Getting help and consulting with professionals is an important step in planning an animal waste management system.

For planning, site evaluation, engineering, and design services, consult:

- Natural Resources Conservation Service (NRCS), U.S. Department of Agriculture (USDA);
- Idaho State Department of Agriculture (ISDA);
- Division of Environmental Quality (DEQ), Idaho Department of Health and Welfare;
- Cooperative Extension System (CES), University of Idaho;
- Independent consulting engineers in your area. They can provide planning, design, and construction specification services;
- Waste handling equipment manufacturers;
- Local planning and zoning commissions. They will know about any restrictions in your area.

For more information about animal waste management, contact:

- Idaho Cattle Association, Boise;
- Idaho Dairymen's Association/United Dairymen of Idaho, Boise;
- Other local operators with waste systems.
- WWW.ONEPLAN.STATE.ID.US

For financial assistance and information:

- Natural Resources Conservation Service (NRCS-USDA) or Farm Services Agency (FSA-USDA). See county office listing under U.S. Government in the phone book;
- Soil Conservation District (SCD).

Chapter 4 Site Selection

Site selection is the most important consideration in planning new CFO's. When adding or improving a waste management system on an existing CFO, there may be constraints in applying some guidelines. However, the items below should be considered before decisions are made regarding land requirements and location of waste storage facilities.

The more you know about land, surface, and subsurface conditions, the easier it will be to plan a waste management system and handle any problems.

Land & Site Considerations

Land needs of a confined feeding operation will vary with the type of facility and climate conditions. Total area required for an integrated system may be determined as the sum of areas required for each of these components:

- Production area (milking center, corrals, housing, feed area and feed storage);
- Runoff diversion ditches;
- Runoff collection and retention structures;
- Solid/liquid separator;
- Waste storage structure;
- Available land area for waste application;
- Buffer zones around confinement area and/or land application sites, if needed to prevent discharges to surface water or injection wells.

An existing or new CFO in some situations may have limited land area to accommodate both a waste storage facility and enough land to properly dispose of waste. In these circumstances, it will be necessary to make arrangements with neighboring farmers to spread or spray on his cropland or pasture.

Local Weather Conditions

Waste storage systems must be designed to contain processed wastewater, storm event rainfall, and winter precipitation runoff. Due to differences throughout the state, precipitation calculations should be based on the local situation.

Rainfall: Find the amount of rain generated from the 25-year, 24-hour storm event for your area (see Figure 2). This is a minimum rainfall storage requirement under the EPA general permit.

Winter Precipitation: Additional storage must be allowed for runoff from three inches of winter precipitation or the amount of runoff calculated from a one-in-five-year winter (See Table 7).

Wind Direction: Prevailing wind direction is important, relative to human occupancy in the area and potential odor, dust, and aerosol drift problems.

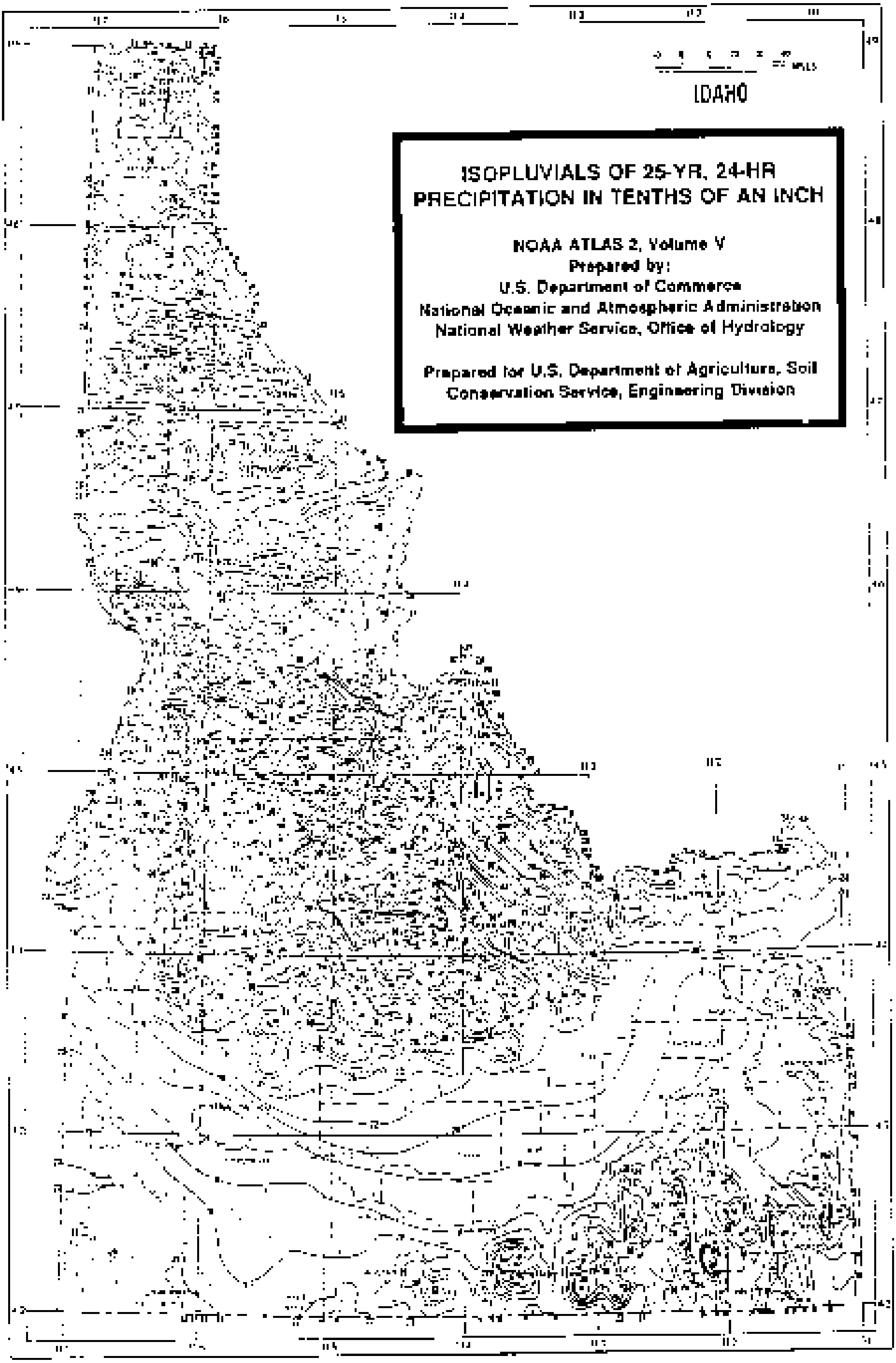


Figure 2. Precipitation in tenths of an inch from 25-year, 24-hour storm in Idaho

Land Use and Human Occupancy

Urban development, zoning ordinances, proximity of residences, business, recreational areas, roads, and highways need to be considered. The recommended minimum distances from a waste storage facility are:

- Domestic well: 100 feet, 200-300 feet preferable;
- Public well: 1,000 feet (from Wellhead Protection Program);
- Property line: 300 feet.

The above distances can be modified based upon site specific conditions, and appropriate professional judgement.

Expected growth of residential areas should always be considered in site selections. In some cases, zoning requirements may be more restrictive than these recommendations. Contact your local county office of planning and zoning for specific information. See listing under County Government in the phone book.

Surface and Subsurface Geology

Geologic factors must be considered, including topography, as steeper slopes may increase amount of surface runoff. Soil characteristics, type, depth, and drainage, affect pollution potential from waste storage and land application. The occurrence of bedrock, fractured rock, or alluvial gravels and sand will increase potential for leaching. Special construction techniques and land application methods of livestock wastes will be required for some sites.

Local Hydrology & Hydrogeology

The location and distance to surface water (streams, canals, drains, lakes), need to be considered. Corrals, housing, and waste facilities should be located to minimize potential discharges. A facility should be sited outside areas frequently flooded or with frequent high water. Ground water depth and flow direction should be considered, and the bottom of a sealed storage pond should be located a minimum of two feet above the seasonal, maximum ground water level.

Chapter 5 Controlling Animal Access to Surface and Ground Water

Animal access to surface and ground water (streams, canals, drains, lakes, ponds) must be controlled to minimize wastes deposited directly in water and prevent stream banks and beds from damage by trampling.

Location

Install or relocate corral fences to prevent confined animals from entering surface waters. The space between a corral and surface water creates a buffer zone that prevents corral runoff not collected in the waste system from entering surface water. It may be necessary to construct a channel, dike, basin, or other collection and/or storage facility for interception of runoff from the corral.

Locate corrals outside of areas frequently flooded or with frequent high water.

Water Development

Provide an alternate watering system such as a trough instead of direct access to surface water.

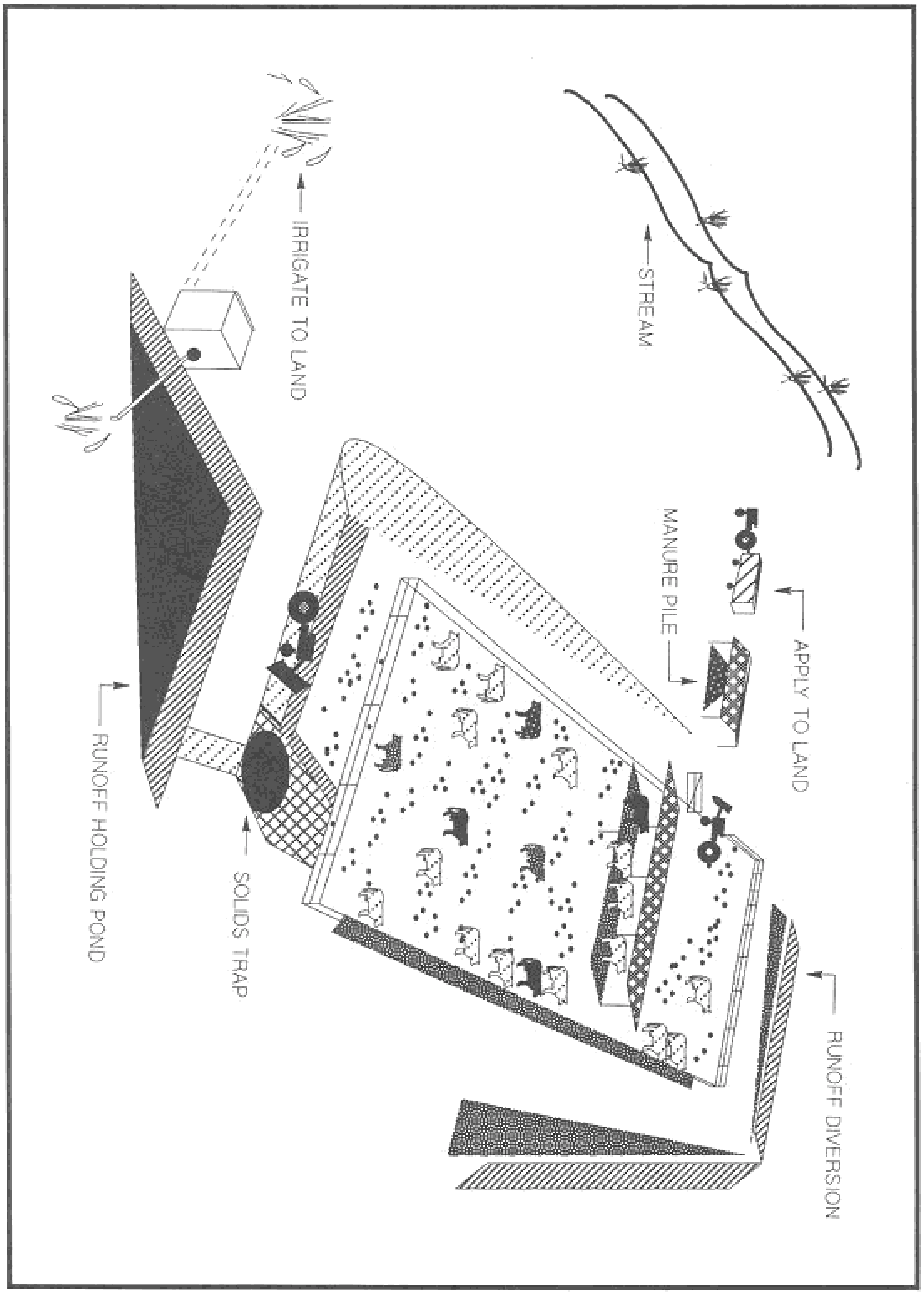


Figure 3. Typical runoff control system for corrals.

Chapter 6 Minimizing Wastewater Volumes

Confined feeding operations should be designed so the waste management system only has to process wastewater necessary to the operation. Water, uncontaminated by animal wastes or other wastes from the confined feeding operation, needs to be handled without going through the waste management system, reducing capacity requirements for handling, storing, and using waste.

Runoff Water Diversions

Diverting surface runoff from entering the confined animal feeding area may require ditches, dikes, terraces, channels, or gutters surrounding all or part of the operation to prevent uncontaminated runoff from entering the confinement or waste storage areas:

- Diversions used below high sediment-producing areas should be designed to prevent damaging accumulations of sediment;
- General design criteria for diversion ditches based on size for a peak runoff from a 25-year frequency, 24-hour storm include:
    - Minimum freeboard of 0.5 feet,
    - Channel designed with stable side slopes;
    - Channel velocity (controlled by the slope) not to exceed that considered non-erosive for the specific soil type;
    - Adequate, non-erosive outlet, such as a grassed waterway, vegetated area, or stable watercourse.
- Construct water bars or cattle guards to intercept and divert road runoff that may enter confinement area;
- Install gutters and downspouts to intercept roof runoff and route to "clean" water diversion.

Water Conservation

Evaluate and minimize water use as much as possible:

- Reduce water use for cooling, cleaning, flushing, and washing animals;
- Reuse wastewater for flushing manure from barns (see Figure 4);
- Maintain clean, dry bedding for animals. Cleaner animals will reduce volume of washwater needed;
- Install timer on any automatic wash-down equipment.

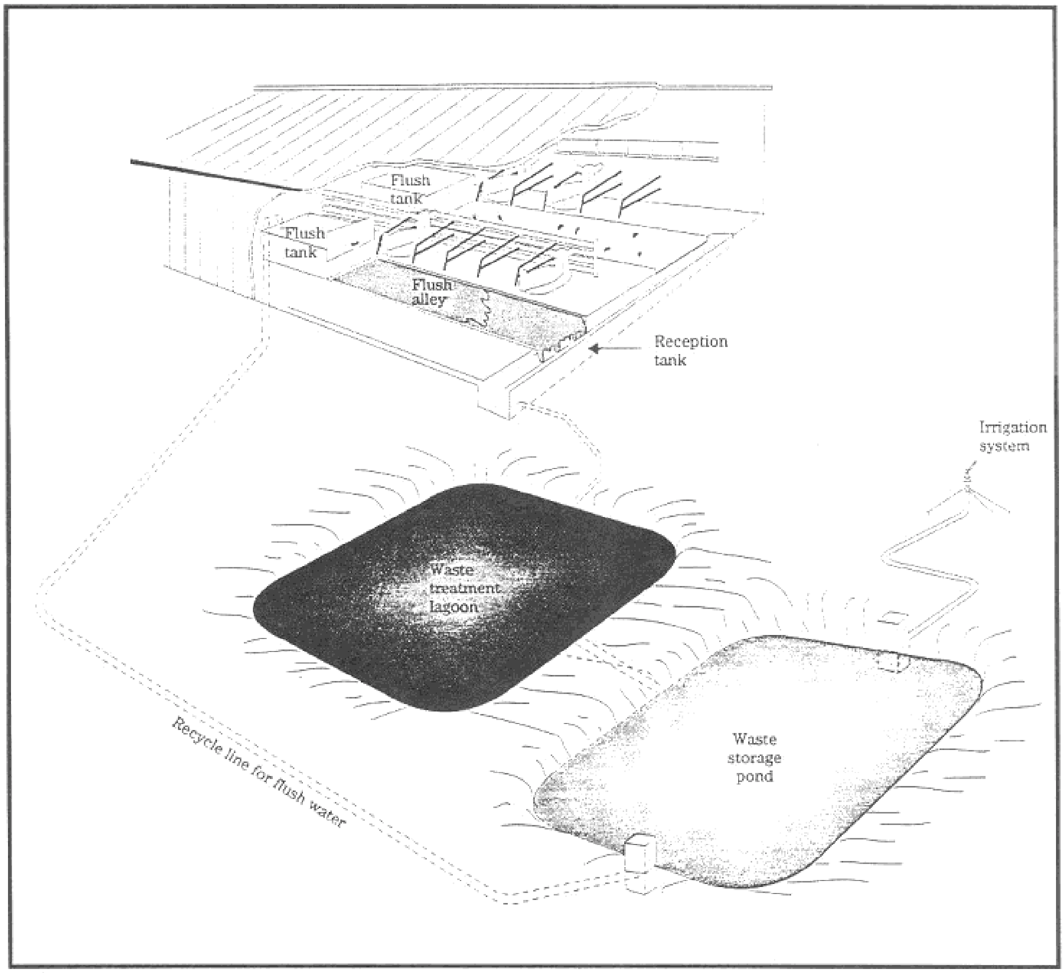


Figure 4. Wastewater flushing system.

Roofing

Roof construction to exclude precipitation may be feasible for some operations where locally heavy rainfall or snow occurs. For example, dairies may want to roof feeding areas to minimize runoff volumes that need to be stored:

- Roof portions or all of resting/feeding areas;
- Roof solid manure storage area;
- Roof milking center.

Chapter 7 Management of Precipitation Runoff

In most feedlots, manure, moisture, and constant animal traffic form a compacted layer impeding water movement into soil. In these situations, most rainwater would be expected to run off and/or remain on the corral surface. Runoff from rainfall or snowmelt which comes in contact with manure in housing, corral, or stack areas is considered wastewater and should be collected, stored, and subsequently applied to cropland, in accordance with Chapter 10, Nutrient Management.

Precipitation Runoff Volume

The volume of precipitation runoff to be retained is based on a 25-year, 24-hour storm rainfall plus the one-in-five-year runoff from winter precipitation (see Table 7). Factors affecting runoff from rainfall are:

- Characteristics of the corral surface;
- Size of corral area.

See Chapter 9, Estimating Storage.

Collection Options

Collection options for runoff from a corral are:

- Gravity flow directly to a settling basin, then to storage;
- Gravity flow to a ditch which transports waste to a settling basin, then to storage. This system usually consists of deep, narrow, and steep, fast-flowing ditches. It is used to transport total runoff, liquid and solid, to collection areas (see Figure 5). Earthen ditches used to convey waste to storage/collection areas and points of application must be appropriately lined to prevent infiltration of nutrients to ground water.

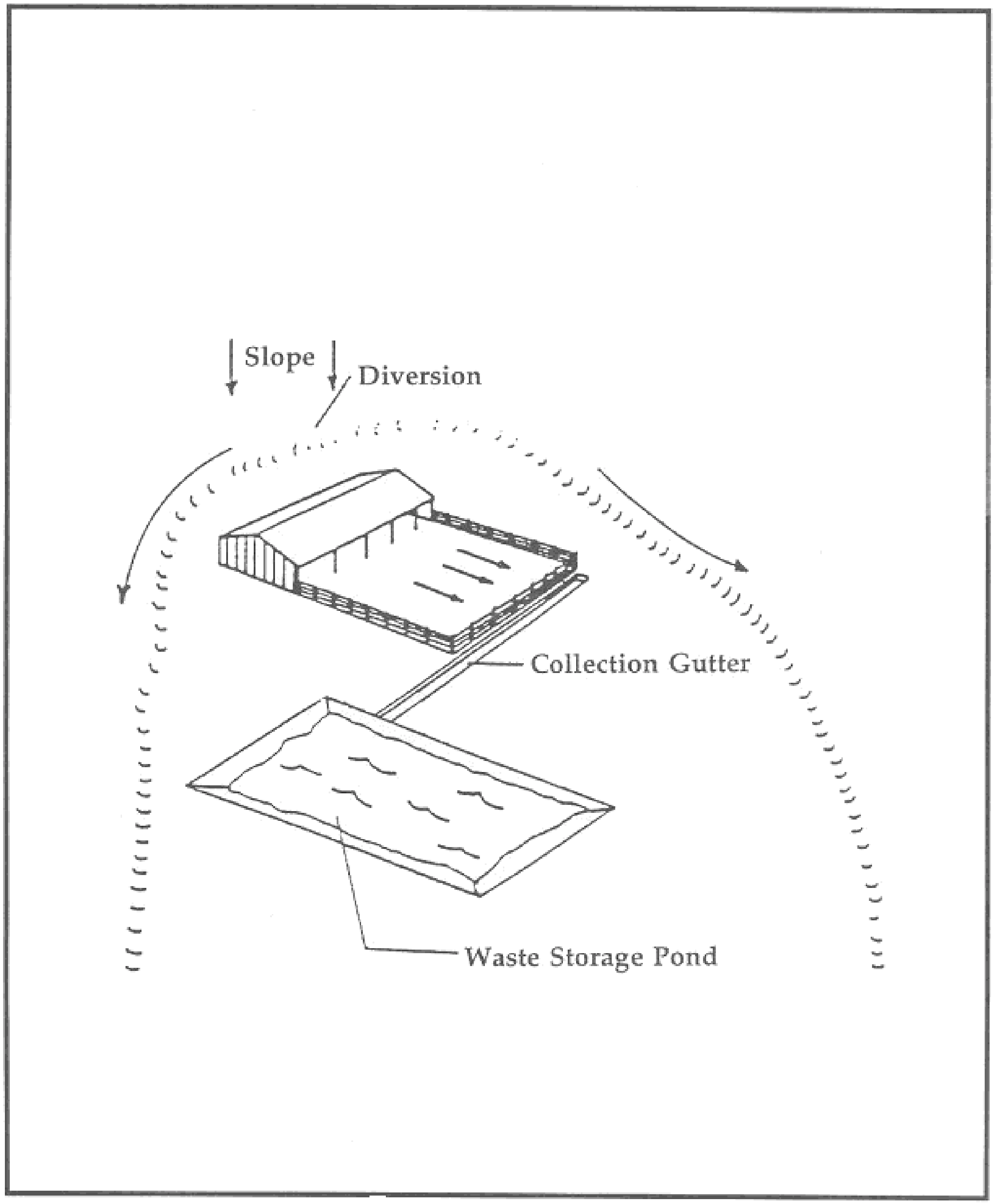


Figure 5. Diversion of "clean" water around feedlot.

Chapter 8 Waste System Components and Design Criteria

The waste management system in a CFO involves handling, storing, and disposing of manure and liquid waste produced while animals are confined. This management has become an important part of the overall planning and operation of the CFO, since the capital investment and labor required contribute to production costs.

Operational Considerations

Each manure system has advantages and disadvantages, and no one system is best for all farms. Considerations in choosing a system include investments, labor, convenience, aesthetics, regulations, and personal preference. Developing the best system for a CFO also requires considering size of the operation, sources of manure and wastewater, cropping practices, soil types, topography, proximity to neighbors, etc.

A waste management system must be planned, designed, and managed to:

- Prevent pollution of surface or ground water;
- Control odors;
- Eliminate breeding places for insects;
- Provide a convenient and efficient operation for the operator;
- Require minimal investment, maintenance, and operational costs;
- Meet legal requirements.

Proper management of manure, wastewater, and feed ensures further benefits in providing a healthy environment for animals. Disease organisms cannot thrive in a facility that is clean, dry, and manure-free. This chapter describes systems suitable for solid, semi-solid, and liquid types of manure handling systems. Any plan for, or modification of, a CFO should consider all the alternatives for manure management and allow for equipment breakdown, vacations, sickness, and changes in technology or farm management. Alternatives for farm management, housing, and manure handling and disposal should be considered, along with leasing equipment, custom hiring, or sharing equipment with a neighbor.

Manure Considerations

The moisture content of manure partially determines how it can be handled and stored. The manure produced by replacements and mature animals varies in moisture content, depending on species, feed rations, and amount and type of bedding used. Manure can be classified according to three consistencies: Solid (16 percent or more solids), semi-solid (12 to 16 percent solids), and liquid (12 percent or less solids).

Solid manure contains considerable fibrous bedding and is easily handled with a front-end loader and conventional manure spreader. In most cases, it can be stacked. Excess water, such as runoff, leaking water tanks, etc., must be kept out of manure.

Semi-solid manure generally contains some bedding and can be handled with a front-end loader and a conventional or flail spreader. It will flow to some extent, but is too thick to agitate and pump with liquid manure handling equipment.

Increased amounts of bedding make semi-solid manure more solid. Precipitation and freestanding water should be drained away from storage. Otherwise, semi-solid manure becomes the consistency of liquid manure.

Liquid manure usually contains little or no bedding, and water may be added so it can be agitated into a liquid consistency and handled with a liquid-manure pump and liquid-manure spreader. If liquid manure is handled with irrigation equipment, considerable quantities of water must be added.

Basic System Types

When evaluating manure storage options, it is desirable to consider both advantages and disadvantages. The storage system option must work with other management practices in the operation. For example, in a dairy operation, the cow management system and type of facilities have a big impact on the manure system chosen. It should be safe, expandable, compatible with pollution regulations, and capable of handling all sources of manure. The following summary of options commonly found in Idaho is intended as a guide and not all-inclusive.

Daily Land Application

Advantages: Only manure is hauled, not precipitation. Investment in equipment is low, and workload is distributed throughout the year.

Disadvantages: A separate management system is required for yard runoff and wastewater from the milking center or other production areas in livestock operation. Equipment life is shortened by corrosion, wetting and drying and daily trips through the mud and snow. Extra time for equipment maintenance and startup is required. More time is required on a daily basis, even during the rush of planting and harvesting. Priority must be given to hauling. Manure must be hauled regardless of weather conditions, and land may be unavailable for spreading during the crop production season. Hauling on wet ground may cause more soil compaction and rutting. Nutrients are lost during long-term exposure of applied manure. The potential is great for pollution and loss of manure nutrients due to runoff, especially on sloping fields. Under certain climatic conditions, geographic locations, soil types, topography and cropping practices, daily land applications would be illegal. The regulatory agency may require the livestock operator to provide documentation that ground and surface water will not be adversely impacted.

Uncovered Storage Facilities

Advantages: All discharges, such as manure, milking center wastewater, and feedlot runoff, can be handled in one system. Since no roof is needed, open storage facilities cost less than covered ones. Dangerous gases do not accumulate.

Disadvantages: With open storage facilities, manure generally needs to be handled as a slurry or liquid. To produce semi-solid manure, precipitation must be drained from the storage area via a picket dam or the equivalent. If slurry handling is chosen, the bedding must contain minimal amounts of fine-textured material. The workload is concentrated during planting and harvesting. Obnoxious odors are released at the time of agitation and spreading of liquid manure. An open storage must be fenced to keep out children and livestock. There is potential for pollution due to runoff.

Stacks

Advantages: Stack systems can accommodate large quantities of long, fibrous bedding and can be used in areas of shallow depth of soil, bedrock, or ground water. No agitation is required and much of the manure is always in a ready-to-haul condition.

Disadvantages: A separate management system is required for runoff from the yard and stack and for wastewater from the dairy milking center. Separate equipment is needed for handling manure liquids and solids. Large quantities of concrete may be required. Freezing temperatures present problems unless the stacker is movable. Collection and treatment of leachate may be required.

Composting

Advantages: The composting process is achieved by using aerobic microorganisms to decompose organic materials into stable form. Composting is generally conducted under controlled aerobic conditions. Temperatures of 130 to 160 degrees Fahrenheit are commonly achieved, providing pathogen kill and desiccation of weed seeds. The major advantage of composting is the production of a stabilized product that can be stored or spread with little odor or fly-breeding potential. There are also fewer trips to field. Improved physical properties include low moisture content, uniform particle size, friable texture, reduced materials volume, and reduced weight.

Disadvantages: The major disadvantage of composting is cost of equipment and labor. Market demand for compost may be temporal, and malodor is usually produced in the initial stages. Even though composting results in a stable material, many nutrients are lost during the process. Approximately half the organic matter, 10 percent of potassium, and up to 40 percent of nitrogen can be lost during composting.

Wetlands

Advantages: A constructed wetlands treatment system provides an efficient low-cost, low maintenance method for treating livestock waste. Man-made marshes can receive daily accumulation of waste and remove potential pollutants through natural decomposition. Treated water is discharged at the end.

Disadvantages: It may take a large amount of area to treat all waste produced by the operation. There also could be a sizable investment for construction. The outflow coming from the wetland may require a point discharge permit, depending on operation location.

Earthen Bank with Earthen Floor

Advantages: Both milking center wastewater and barn manure can be stored together in liquid systems. Earthwork results in low-cost construction, and such storage can be filled in easily and a new one constructed, if expansion occurs. Storage can be located next to the barn.

Disadvantages: Considerable land area is disturbed during construction. Strong odor occurs during agitation and spreading. Load-out equipment cannot be operated on the earth floor. Ground water may be polluted in areas of fractured rock strata, if ponds are not sealed. Concrete or other linings may be necessary.
Fencing is required to keep people and livestock out of storage. Above ground earthen banks are subject to rodent intrusion.

Earthen Bank with Concrete Floor

Advantages: Milking center wastewater and barn manure can be stored together in dairy liquid systems. Earthen bank storage facilities with concrete floors can handle semi-solid as well as liquid manure, if entrance ramp is constructed and provisions are made for separating precipitation from manure (picket dam). Concrete floors are recommended in vulnerable ground water areas, such as fractured bedrock or high water tables.

Disadvantages: A semi-solid manure system may require precipitation and milking center wastewater to be handled separately from manure. Considerable land area is disturbed during construction. Fencing is required to keep people and livestock out. If manure is handled as a semi-solid, a concrete floor and picket dam increase installation cost. Above ground earthen banks are subject to rodent intrusion.

In Ground Tank

Advantages: Generally, no pumps are needed to fill the storage facility, and a minimal amount of land area is required. A roof can be added to keep out precipitation.

Disadvantages: The manure must be handled as a slurry or liquid and must be pumped out of the storage facility. Bedding must be short material and limited in quantity. The floor is usually poured-concrete construction with steel reinforcement. Walls may be poured-in-place reinforced concrete or pre-cast reinforced concrete. Because tanks must be watertight, construction and operation of these storages in areas with high water tables can cause problems. Strong odor occurs during agitation and spreading. Drowning is a possible hazard, and toxic and explosive gas can build up, if the storage facility has a cover.

Above-Ground Silo or Rectangular Tank

Advantages: Above-ground storage tanks can be constructed in areas with shallow bedrock or where the depth to ground water is shallow. A minimal amount of land area is required. When ladders are removed, it is difficult for unauthorized persons to gain access to such a storage unit.

Disadvantages: Manure must be handled as a slurry or liquid, and only a minimal amount of fine bedding can be used. Manure must be pumped in and out of storage unless the elevation is sufficient for gravity flow. (Back-flow protection is necessary.) Agitation and removal of solids from the large-diameter storage facilities may pose a problem, and strong odor occurs during agitation and spreading.

Bedded Pack

Advantages: A wide choice of bedding materials can be used, and no special manure storage is necessary. To keep costs low, manure can be handled with a front-end loader and box spreader. Power requirements for loading and spreading are also lower than with liquid systems. Manure is available for hauling at any time. Cattle are housed on the bedded pack, so no additional area is needed.

Disadvantages: Bedding must be added frequently and in large quantities to keep cattle clean. Building walls must be high enough to allow for buildup of the manure pack and strong enough to withstand the force of pack and unloading equipment.

System Design

The type of waste system to use is determined by the amount and type of waste to be handled. In many cases, two or more methods of handling wastes are used within a single operation. For example, it is common in dairies for waste from the milking operation to be handled separately from feeding and housing area waste. The system designer must determine the amount of waste deposited within a given area of the facility (see Table 3).

Most animal waste is deposited in feeding and housing areas. In many cases, it is more economical to handle wastes from housing and feeding areas as a solid, keeping it separate from highly liquid wastes found in dairy milking centers. Many operators flush holding pens to clean them and use sprinklers to clean cows. Both practices will make it impractical to handle this portion of the waste as a solid. Milking parlor waste is nearly always liquid because of the volume of water used to clean the milking center and wash cows. The following factors are important in designing a waste storage system:

- Number of storage units to be used;
- Type of manure stored, solid or liquid (see Table 11);
- Type and amount of bedding used (see Table 5);
- Number and weight of animals;
- Daily expected volume of waste;
- Area contributing to surface runoff and amount of runoff expected;
- Newly constructed facilities require a minimum of 180 days storage. This storage requirement may increase in areas with a shorter growing season.
- Environmental considerations.

Calculations for determining waste storage are straightforward, and the primary concern is containing all waste produced. Determining proper storage size involves calculating the volume of waste produced and the size of structure to hold it.

Storage Basin

A storage basin is an impoundment made by excavation or earthfill for temporary storage of animal waste and is the most basic component of a waste management system. An earthen basin can be used as a settling facility and for runoff collection. It can also be used to temporarily store all forms of waste, solid, semi-solid, slurry, or liquid.

Storage capacity should be determined based on minimum EPA permit requirements, if applicable, or length of storage time, available space, and volume of waste to be stored. Both surface area available and depth may be limited, the latter because of soil and subsurface conditions. See Chapter 9, Estimating Storage.

Design Recommendations

Locate basin close to waste sources, but maintain recommended distances. These distances can be modified based upon site specific conditions, and appropriate professional judgement. Check county planning and zoning requirements for minimum distances:

- 100 feet from a stream, and a vegetated buffer strip is recommended;
- 100 feet from a private water supply, 200-300 feet preferable;
- 300 feet up gradient from a private water supply, 300-500 feet preferable;
- 100 feet from any residence, 300-500 feet preferable;
- 1,000 feet from a public water supply, or other distance as determined by a Wellhead Protection Plan;
- Allow for expansion plans.

Seepage control must be provided to prevent contamination of ground water and/or a water supply well:

- A subsurface investigation may be required to evaluate soil/bedrock characteristics and ground water conditions. Consult with NRCS and the appropriate regulatory agency;
- Construct to an elevation of at least two feet above seasonal high water table;
- Allow some solid accumulation in the bottom to facilitate natural sealing;
- In areas of permeable soils, high groundwater table, and/or fractured bedrock, a sealant such as bentonite or a synthetic liner is required to prevent seepage.
- If bentonite is used, it should not be allowed to dry out during or after installation;
- Consideration should be given to methods of solids removal to prevent disturbance of the seal;
- Depth to the water table must be considered in designing depth of basin.
- Hydraulic and organic loading must be considered in design of basin;
- Sealing may be accomplished by proper compaction of existing soils. Soils need to be evaluated before making this decision. Amount and types of soil must conform to the requirements of USDA Tech Note 716-Rev. 1 as amended. The appropriate regulatory agency will review and approve this process. After clearing and scarifying, maximum density is achievable with proper moisture and compacting equipment;
- If a synthetic liner such as PVC or polyethylene is used, quality control during installation is essential for proper functioning. Manufacturer's specifications for material thickness and installation must be followed. The most important aspects of installation are:
- Clearing soil base to remove roots, stones, or other objects that could puncture the liner;
- Proper seaming procedures and materials that follow manufacturer's specifications;
- Laying six-inch protective earth layer, free of sharp objects, on top of liner;
- In areas with high organic content in soil beneath the structure, or where gas may still be produced, the liner needs venting capabilities or it may float.

Bottom design is based on maintenance efficiency:

- A three to four percent sloped bottom toward pump-out points;
- Where vertical shaft pumps are used, a concrete pad should be placed at pump-out access to prevent scouring.

The earth embankment design should include:

- Inside slopes a minimum of 2:1 (run:rise);
- Outside slopes a minimum of 3:1;
- Design height increased by at least five percent to ensure top elevation is maintained after natural settling,
- Top width of eight feet, unless height of embankment is less than 6 feet above ground, in which case the embankment top width should be at least as wide as the height (Federal cost share will require a minimum eight foot top width regardless of the height);
- Vegetated outside slopes to control erosion;
- Use practices that reduce rodent habitat.

Access ramps should be built with reinforced concrete at least five inches thick, sloped no steeper than 7:1, and have a raked surface. Fill should be well-compacted with proper equipment according to soils. Figure 6 shows three variations on access.

Inlet and outlet should be a permanent structure to resist erosion, plugging, and damage by ice. If slurry and solid waste are stored here, inlet should be designed to deposit waste near center of basin. The outlet must not be able to release stored material automatically. An emergency spillway also needs to be provided to ensure the dike will not overtop in the event of a release greater than the designed volume.

System Maintenance

Maintenance is required for any waste system component to function as designed:

- If a majority of solids are stored in a basin, provisions must be made for periodically removing them to preserve storage capacity for runoff and storm events without disturbing the seal;
- After a storm event or if basin is full, liquids must be removed to maintain the emergency capacity required for another storm event.

Safety

Safety provisions may be necessary if basin is located so that it is a safety hazard for children and/or animals. Fences and warning signs generally meet these needs. A dried manure surface can be deceptive.

Solid Manure Storage

Handling as much waste as possible in solid form is recommended to minimize the need to remove solids from liquid waste storage basins. Therefore, it is desirable to construct settling basins or channels and design housing or corrals for periodic removal of partially dried, solid manure. In addition, a dairy operator may want to handle all wastes from dry cows and heifers (generally 17 percent of the herd at any one time) as a solid. This generally requires more labor and a separate storage area, but less specialized pumping and handling equipment.

The first step in removing manure from the lot or corral surface is scraping it into piles or windrows. Care should be taken not to disturb the manure pack on the lot or corral surface. This pack reduces movement of moisture and pollutants downward into the water table. Once manure has been scraped, it may be removed from the feedlot with a front-end loader. If manure is to be stockpiled for sale or later application to cropland, large carryalls or trucks with front-end loaders may be used to transport it to a suitable storage area. If manure is to be transported immediately to a land application site, spreader trucks should be used. Manure may also be mounded to dry within the pen and left for cattle to lie on in wet weather.

Location of the storage area should be away from streams or wells and on a material of minimal permeability to prevent seepage into ground water. Berming may be required to prevent runoff. If maintained, a compacted soil and manure layer as found in a confinement lot usually provides an adequate floor for mounding dry manure. It should also be located for year-round access so manure can be spread when field conditions and weather permit.

Calculate capacity by figuring volume of solid manure produced from the operations over a minimum four-month period. If bedding is used, that should be figured into the volume. An average reduction of one-half the original volume of bedding is suggested. For more flexibility in timing land application of manure, provide for six months of storage.

Design recommendations for a concrete slab with buck wall(s):

- Concrete base at least five inches thick, graded two percent or less away from load point (thicker concrete or added reinforcing may be required);
- One or more walls to control drainage and buck manure against will reduce floor area needed. One option is tightly-fitted wooden planks;
- A roof will keep precipitation out;
- Drainage from the stack must flow to the liquid storage basin or grassed area with low permeability soils. Drainage must not be allowed to enter surface waters;
- Provide for convenient filling with a tractor-mounted manure loader or scraper, elevator stacker, blower stacker, or piston pumping system;
- Unloading is usually accomplished with a tractor-mounted bucket or manure bucket;
- A stacker loaded storage should be designed to accommodate stacker height. This system generally is used for confinement stall barns and where terrain does not allow a loading dock or ramp. Freeze-ups may make this system impractical.

Liquid-Solid Separation

It is desirable to separate liquids from solids for ease of handling and to minimize frequency of solids removal from liquid storage basins. An effective solids removal system will significantly reduce size of the storage basin required. Separation is accomplished by gravity, screens, filters, or evaporation of water. After separation, solids can be land-applied immediately or stored and dried for later use. Liquids are then easier to handle for land application or recycling for flushing. Separation may also result in reduced odors from storage basins.

Settling facilities may be designed to intercept the total lot runoff, settle out most solids, and release liquids to a storage pond or infiltration area.

Extended periods of wet, freezing weather need to be considered in the design. Settling facilities may also be designed to intercept dairy barn and milking parlor wastes to settle out solids. The primary design recommendations are the desired maintenance cycle, weekly, monthly cleaning schedule, land application schedule, etc., and estimated percentage of manure entering that will settle out, dry, and be removed as a solid.

Settling Channel

A settling channel can be used for transport to a storage pond and for solids removal. It is a wide, shallow, gently sloping, flat-bottomed waterway in which runoff solids will settle due to low velocity of moving liquid (see Figure 7).

Design recommendations:

- Side slopes 3:1 or less;
- Bottom slopes 0.1 percent to 0.3 percent (1 to 3 ft./1000 ft.);
- Variable flow design, where a faster flow is maintained (two feet per second or fps) in the first 50 to 100 feet section to settle out large solids, and a slower flow is maintained (0.5 fps) in the following section to settle out smaller solids; or uniform flow design, where a constant flow is maintained (generally one fps);
- Screens or removable porous dams can be used with the uniform flow design in areas with less than 25 inches of precipitation per year. Screens trap solids and permit liquids and small particles to pass. Small screen openings trap more solids but require more cleaning. Porous dams can be constructed of spaced boards, welded wire fabric, or expanded metal mesh which can be scraped clean.

Maintenance: Settling channel should be cleaned regularly when accumulations reduce channel volume and when sufficient drying permits handling with scraper and loader.

Settling Basin

A settling basin is an earthen or concrete basin designed to settle or screen out solids by reducing velocity of runoff (see Figure 7).

Design recommendations (structural criteria will be the same as for earthen storage basins):

- Liquids need to drain into a storage basin in a controlled manner;
- Porous dam or screen permits liquid to drain off. Spaced boards, welded wire fabric, or expanded metal mesh can be scraped clean;
- Perforated pipe outlets are usually of PVC plastic, galvanized steel, or concrete. Flow rate is controlled by holes or slots used per vertical foot of pipe;
- Two settling basins, parallel to each other, are recommended so one may be used while the other is cleaned or maintained;
- A concrete basin is more expensive to install, but many operators find maintenance is trouble-free and efficient (see Figure 8).

Maintenance:

- Basin should be cleaned on a regular schedule based on storage capacity;
- Outlets should be cleaned after each runoff event;
- Basin seals must be maintained during cleaning.

Other Separation Methods

Screening and Filtration (see Figure 9): Commercial screening and filtration systems are available for treating livestock wastes. In general, they produce a solid with about 70 to 80 percent moisture content.

There are several screening methods. One has a stationary screen mounted on an incline with slurry applied to the top edge of screen. Liquid passes through it and is drained away. Solids move down the face and drop into a storage area or conveyor.

The second method has a rapidly vibrating screen. Vibration aids movement of solids across the screen and reduces clogging. There are many vibrating screen configurations.

Another method has a rotating screen. Slurry passes between cylindrical screens and press rollers in several steps. The liquid passes through to the center of the screen and out the other side for discharge. Solids are conveyed to the next screen section and then to storage.

In another method, slurry is applied to the top of a porous belt which passes through rollers. Liquids are pressed through by the rollers, and solids are carried along on the belt. This system has been successful with livestock waste.

Evaporation Ponds: Where evaporation exceeds precipitation, evaporation ponds can remove water from livestock wastes. In arid regions, evaporation can be as much as 24 inches greater than rainfall. Design an evaporation pond large enough to accumulate all wastes during the wet season, plus runoff from the 25-year, 24-hour storm. Increasing land values may discourage evaporation ponds except in low-rainfall, high-evaporation areas. Sealing requirements are the same as for storage basins.

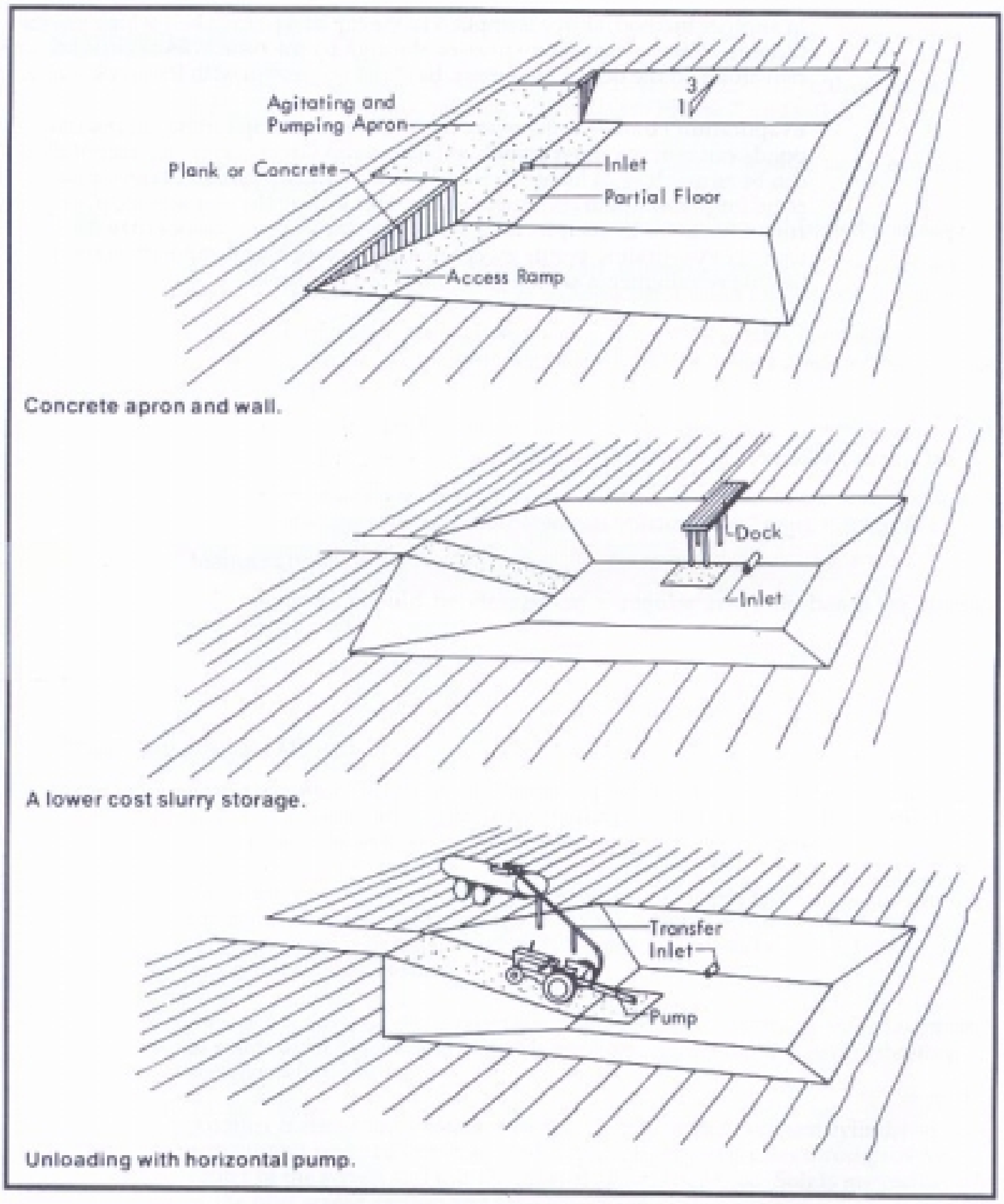


Figure 6. Access ramps.

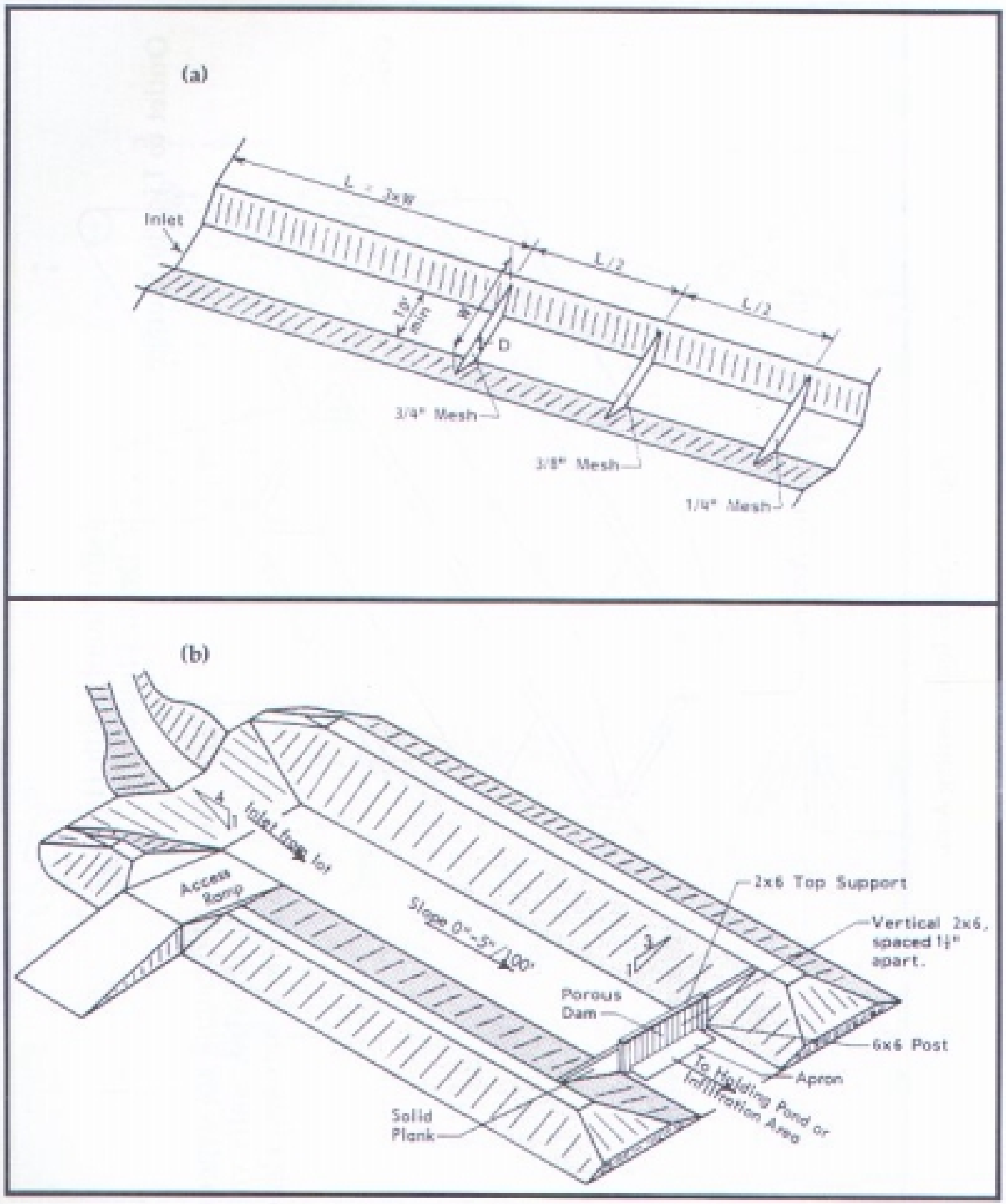


Figure 7. Typical design for earthen settling channel (a) and settling basin (b). Source: *Livestock Waste Facilities Handbook*, Midwest Plan Service, 1980.

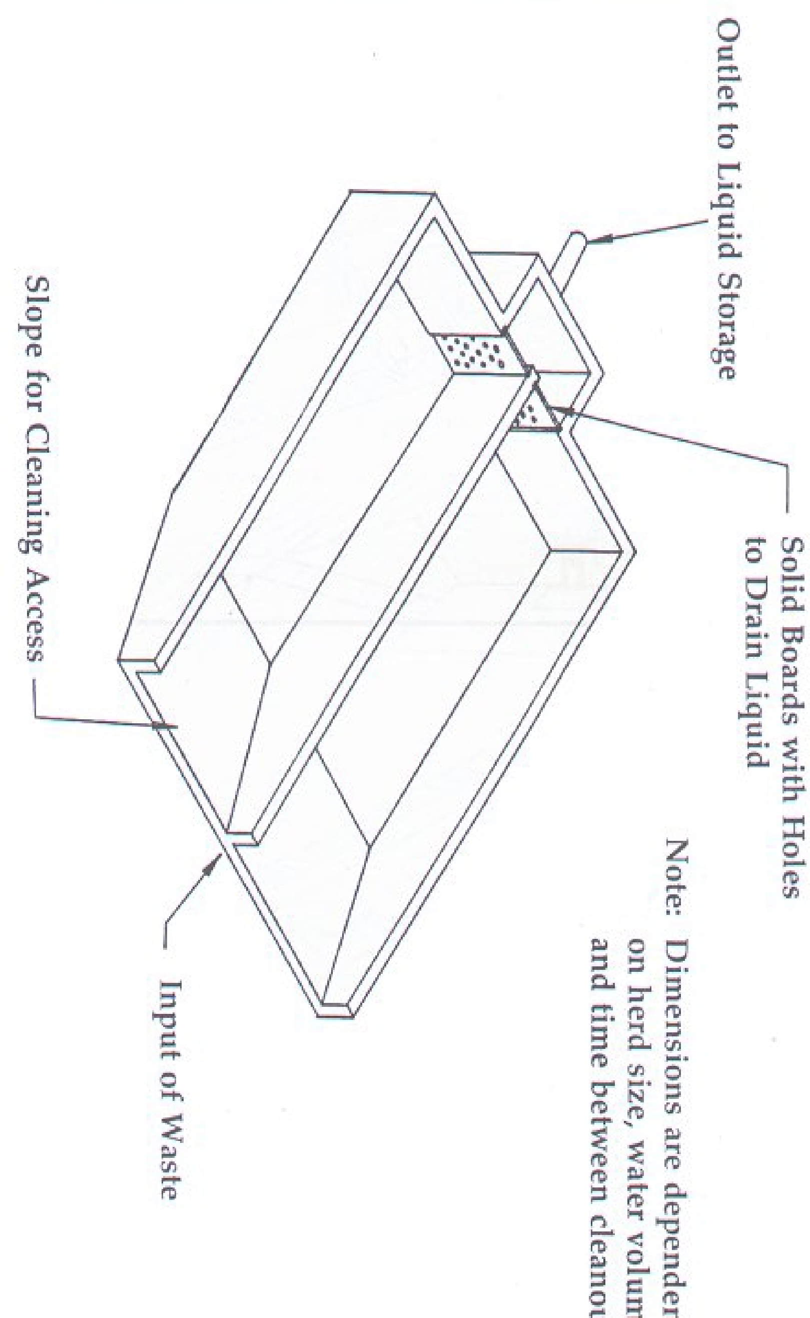


Figure 8. Solid-Liquid Settling Area.

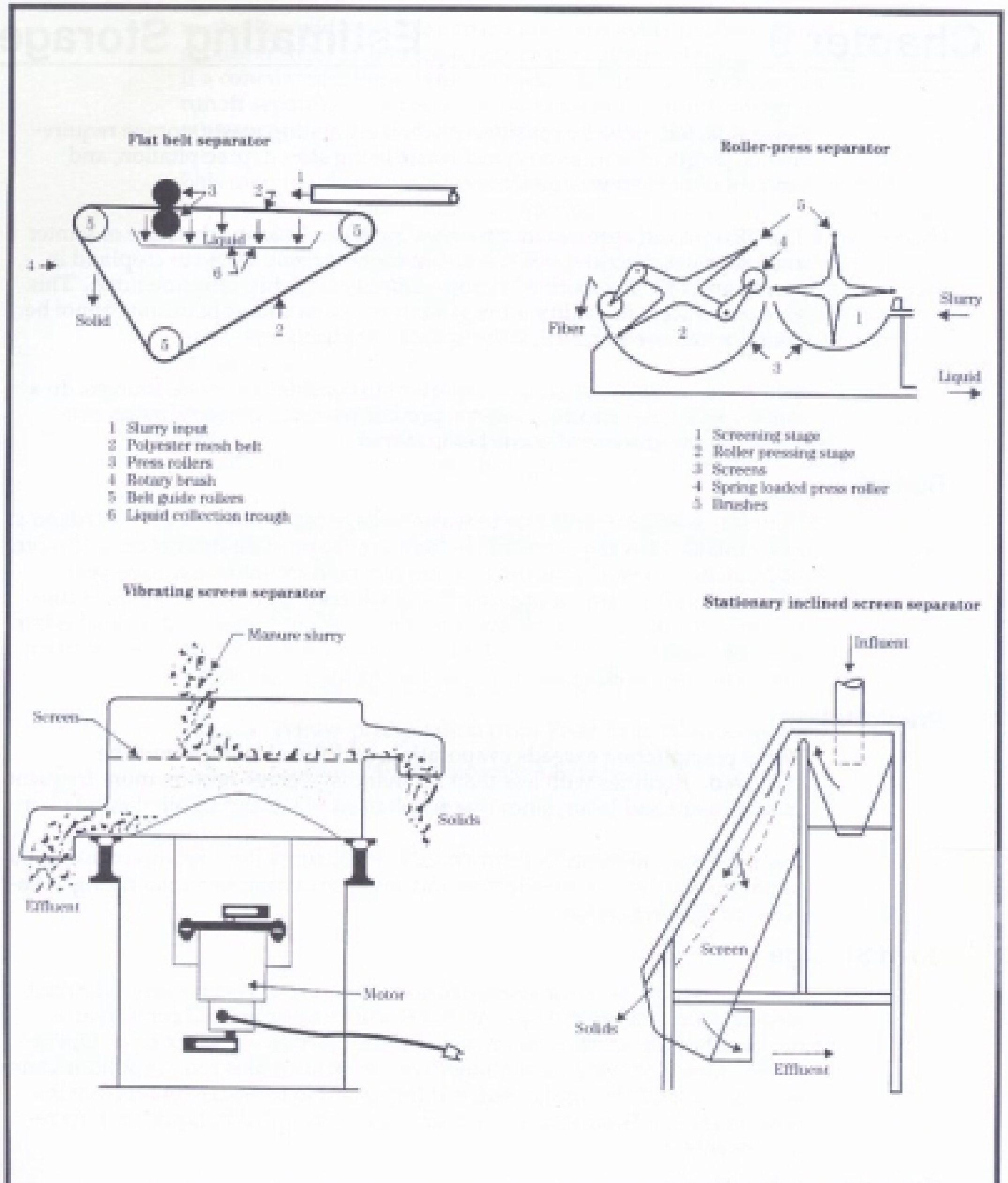


Figure 9. Schematic of mechanical solid-liquid separators with screening and filtration mechanism.

Chapter 9 Estimating Storage

Several factors must be considered when estimating waste storage requirements, length of time and type of waste being stored, precipitation, and amount of process wastewater.

The EPA permit requires four month storage. In Idaho, because of winter and cropping practices, it is not uncommon to apply waste to cropland in spring and fall. Six month storage capacity is highly recommended. This gives producers flexibility if the ground is frozen and application cannot be made, or when equipment failures delay application.

When estimating storage, it is important to consider all waste sources. In a dairy operation, bedding, manure, process water, and precipitation contribute to the amount of waste being stored.

Runoff

Runoff is a major contributor to waste storage requirements, even in Idaho's dry climate. EPA requirements in Idaho are to provide storage for a 25-year, 24-hour storm event, plus three inches of runoff, or the one-in-five-year winter runoff. In estimating runoff and winter precipitation, all areas contributing to runoff in which water becomes contaminated with animal waste must be included. It is beneficial to divert as much runoff as possible from entering the corral area to eliminate the need for storing excess water.

Precipitation

When precipitation exceeds evaporation, additional storage must be provided. Facilities with less than six months' storage require more frequent management and labor, since waste will need to be land-applied more often.

It is important to estimate future needs. Including future requirements in the initial installation is cost-effective and easier to accomplish than trying to enlarge an existing system.

Solid Storage

It is necessary to plan for storage of solid manure. If corral space is limited, storing solid manure outside the corral will increase animal comfort and health while allowing more animals to be housed in a smaller area. Operations where feed alleys or holding pens are scraped also require solid manure storage. If solid storage is used, it is important to consider runoff from the area where solids are stored. Runoff must be included in liquid storage requirements.

Other Considerations

It may not be necessary to contain all liquid waste in a single storage basin. It may not be practical to store runoff in the primary waste area. In many cases, a containment berm may be used to capture runoff outside the corral. This method provides a large surface area, is usually shallow, and allows a producer to let evaporation reduce the amount of liquid, leaving dry solids. If a containment berm is to be used, it is important to keep non-polluted runoff separate from contaminated runoff to reduce storage and disposal requirements.

This method of estimating waste to determine storage basin size does not take into account accumulation of solids over a period of years. Additional storage space should be allowed for accumulation of solids for the period between clean-out of solids. It is difficult to estimate additional storage required for accumulations of solids. Different designs for emptying storage will result in varying levels of solid removal. Also, some decomposition of solids will occur due to biological processes which will affect amount of solids left to be removed.

Proper operation and maintenance of a storage basin must include a plan for periodic solids removal. Frequency of solids removal will depend upon amount of solids going into the lagoon and method used to empty the lagoon.

The following worksheets are designed to aid in calculating storage requirements. The example used is based on a 200-cow dairy with solid and liquid storage calculations:

- 200 dairy cows, 1,300 pounds average body weight;
- Two acres unpaved lot area with less than two percent slope;
- Runoff contained in storage facility;
- Winter precipitation from Twin Falls WSO Airport;
- 25-year, 24-hour storm is 1.8 inches;
- Long straw bedding used in loose housing;
- 14 days between cleanout, 60 percent efficiency.

MANURE VOLUME WORKSHEET – Example 1

Name:	Date:	Location:	Prepared By:

1. Number of animals in herd	200
2. Average weight of animals in herd	1300
3. Manure volume per day (cubic feet) (Table 11) (line 1 x line 2/1000 x 1.37)	356.2
4. Percent of manure being stored (in decimal) (Table 3)	.85
5. Manure being stored per day in cubic feet (line 4 x line 3)	302.8
6. Contribution of bedding stored with manure in cubic feet per day (line 1 x line 2/1000 x amount from Table 5)	273
7. Cubic feet of manure and bedding per day (line 5 + line 6)	575.8
8. Days of storage required	180
9. Volume of storage required in cubic feet (line 8 x line 7)	*103644

* Refer to Tables 8 and 9.

MANURE VOLUME WORKSHEET

Name:	Date:	Location:	Prepared By:

1. Number of animals in herd	
2. Average weight of animals in herd	
3. Manure volume per day (cubic feet) (Table 11) (line 1 x line 2/1000 x 1.37)	
4. Percent of manure being stored (in decimal) (Table 3)	
5. Manure being stored per day in cubic feet (line 4 x line 3)	
6. Contribution of bedding stored with manure in cubic feet per day (line 1 x line 2/1000 x amount from Table 5)	
7. Cubic feet of manure and bedding per day (line 5 + line 6)	
8. Days of storage required	
9. Volume of storage required in cubic feet (line 8 x line 7)	

STORAGE VOLUME WORKSHEET – Example 2

Name:	Date:	Location:	Prepared By:

1. Number of cows in herd	200
2. Average weight of cows in herd	1300
3. Manure volume per day (cubic feet)q (line 1 x line 2/1000 x 1.37)	356.2
4. Number of milkings per day	2
5. Number of sprinklers in holding pen	0
6. Sprinkler output in gallons per minute (gpm) (@50 psi 9/64 = 4.04; 5/32 = 4.98; 11/64 = 6.01; 3/16 – 7.18)	0
7. Minutes per day sprinklers are used	0
8. Gallons of water used to wash holding pen per day	200
9. Percent of total manure being stored (in decimal) (see Table 3)	0.15
10. Runoff due to 25-year/24-hour storm in cubic feet (see Table 6) 82.5 x 87.12 = 7187 cu ft/1000 sq ft 1000 sq ft	7187
11. Runoff due to winter precipitation in cubic feet (see Table 6) 83 x 87.12 = 7231 cu ft/1000 sq ft 1000 sq ft	7231
12. Milkhouse and parlor volumes (see Table 4)	Gallons
Bulk Tank	60
Pipeline	200
Misc. equipment	30
Wash parlor floor	75
Wash milkhouse floor	20
Holding pen volume (line 8)+(line 5 x line 6 x line7)	200
Cow prep per cow per day (see Table 4) [(use per milking gal) x line 1 x line 4] = gallons	200
Total	785 (/7.5) = cu ft 104.7
13. Manure being stored per day in cubic feet (line 9 x line 3)	53.4
14. Total daily estimated volume in cubic feet (sum lines 12 + 13)	158.1
15. Total estimated volume from runoff events (sum line 10 + line 11)	14418
16. Number of days of storage required (minimum 4 months; 6 months recommended	180
17. Cubic feet of storage required (line 16 x line 14) + line 15	42876

Comments: These calculations do not account for volume changes due to precipitation and evaporation in storage structure. If bedding is stored in structure, adjust volume accordingly. Add cubic feet of volume to line 17. Refer to Table 5.

STORAGE VOLUME WORKSHEET

Name:	Date:	Location:	Prepared By:

1. Number of cows in herd	
2. Average weight of cows in herd	
3. Manure volume per day (cubic feet) (line 1 x line 2/1000 x 1.37)	
4. Number of milkings per day	
5. Number of sprinklers in holding pen	
6. Sprinkler output in gallons per minute (gpm) (@50 psi 9/64 = 4.04; 5/32 = 4.98; 11/64 = 6.01; 3/16 – 7.18)	
7. Minutes per day sprinklers are used	
8. Gallons of water used to wash holding pen per day	
9. Percent of total manure being stored (in decimal) (see Table 3)	
10.Runoff due to 25-year/24-hour storm in cubic feet (see Table 6) 82.5 x 87.12 = 7187 cu ft/1000 sq ft 1000 sq ft	
11. Runoff due to winter precipitation in cubic feet (see Table 6) 83 x 87.12 = 7231 cu ft/1000 sq ft 1000 sq ft	

12. Milkhouse and parlor volumes (see Table 4)	Gallons
Bulk Tank	
Pipeline	
Misc. equipment	
Wash parlor floor	
Wash milkhouse floor	
Holding pen volume (line 8)+(line 5 x line 6 x line7)	
Cow prep per cow per day (see Table 4) [(use per milking gal) x line 1 x line 4] = gallons	(/7.5) = cu ft
Total	

13. Manure being stored per day in cubic feet (line 9 x line 3)	
14. Total daily estimated volume in cubic feet (sum lines 12 + 13)	
15. Total estimated volume from runoff events (sum line 10 + line 11)	
16. Number of days of storage required (minimum 4 months; 6 months recommended	
17. Cubic feet of storage required (line 16 x line 14) + line 15	

Comments: These calculations do not account for volume changes due to precipitation and evaporation in storage structure. If bedding is stored in structure, adjust volume accordingly. Add cubic feet of volume to line 17. Refer to Table 5.

SEPARATOR VOLUME WORKSHEET – Example 3

Name:	Date:	Location:	Prepared By:

1. Number of animals in herd	200
2. Average weight of animals in herd	1300
3. Manure volume per day (cubic feet) (Table 11) (line 1 x line 2/1000 x 1.37)	356.2
1. Percent of manure being stored (in decimal) (Table 3)	.15
5. Manure going to separator daily in cubic feet (line 4 x line 3)	53.4
6. Contribution of bedding stored with manure in cubic feet per day (line 1 x line 2/1000 x amount from Table 5)	0
7. Cubic feet of manure and bedding per day (line 5 + line 6)	53.4
8. Days desired between cleanout	14
9. Daily water volume used in Milking Center (line 12, Storage Volume Worksheet, cubic feet)	104.7
10. Estimated separation efficiency (60% recommended) ___/100 =	.6
11. Volume to be stored per cell (line 7 x line 8 x line 10 + line 9 + line 7) =	*606.7

* Referring to Table 10, a separator with single slope apron floor 3’ deep x 12’ wide with a 40’ apron would provide 696 cubic feet of separation storage, which is adequate for this example.

SEPARATOR VOLUME WORKSHEET

Name:	Date:	Location:	Prepared By:

1. Number of animals in herd	
2. Average weight of animals in herd	
3. Manure volume per day (cubic feet) (Table 11) (line 1 x line 2/1000 x 1.37)	
2. Percent of manure being stored (in decimal) (Table 3)	
5. Manure going to separator daily in cubic feet (line 4 x line 3)	
6. Contribution of bedding stored with manure in cubic feet per day (line 1 x line 2/1000 x amount from Table 5)	
7. Cubic feet of manure and bedding per day (line 5 + line 6)	
8. Days desired between cleanout	
9. Daily water volume used in Milking Center (line 12, Storage Volume Worksheet, cubic feet)	
10. Estimated separation efficiency (60% recommended) __/100 =	
11. Volume to be stored per cell (line 7 x line 8 x line 10 + line 9 + line 7) =	

Chapter 10 Nutrient Management

The overall goal of manure nutrient management is to apply at a rate that safely satisfies crop nutrient uptake, optimizes crop yield, and protects Idaho's water resources.

Because of its nutrient value, manure should be considered a resource instead of a waste. The amount and kind of nutrient value in this "resource" depends on the animal, type of feed, method and length of storage, and method of application. Manure properly applied to land will decompose into soil organic matter and available nutrients essential to plant growth and improved crop yield. Decomposed manure also improves soil tilth, increases water-holding capacity, reduces wind and water erosion, improves aeration, and promotes growth of beneficial soil organisms. Depending on the water content of waste applied, it can also supplement irrigation. The nutrient content, while minimal in diluted wastes, can still be valuable for crop production.

Land application to cropland or pasture is the easiest and most widely adopted technique to recycle nutrients from animal waste. Proper land application can provide nutrients for crops, improve or maintain soil physical condition, prevent erosion, and protect Idaho's water resources. Livestock facilities that fail to properly manage nutrients from animal waste are subject to penalties as outlined in state or federal laws. Livestock facility owners/operators are responsible for the proper application of feed, waste and nutrients from animal waste on land they own or operate.

Animal waste or nutrients from animal waste must be contained in approved waste containment facilities and land applied in accordance with the provisions of this chapter or other methods as approved by the appropriate regulatory agency. Feed or animal waste runoff escaping the boundaries of the livestock facility including land application sites is subject to regulatory penalties. Release of livestock or feed waste into water conveyances that do not terminate on or before the operator's property boundary would be a discharge.

Contract manure haulers and or livestock owner/operators which haul animal waste from any livestock facility to the point of application are responsible for preventing undue spillage, leakage or tracking of animal waste from the boundaries of the livestock facility to the boundaries of the application site. In the event that excessive spillage, leakage or tracking has occurred, the responsible party must immediately rectify the problem. Violations are subject to the penalty provisions of Title 37 Chapter 4 Idaho Code.

Factors to consider in waste utilization are site evaluation, timing of application, application rates, crop rotation, and available land for application. Recording nutrient, COD and salt applications may be necessary to protect ground water, soil quality and crop production.

Site Evaluation

Available land is usually the most serious limiting factor in using manure for its nutrient value. Based on nutrient content of manure, adequate land should be provided for effective utilization. An alternative to lack of adequate land is more efficient "treatment" of waste, such as aerobic or anaerobic lagoons, composting or off-site utilization, or processing to reduce nutrient overloading of soil. For information and to determine application rates and nutrient uptake, refer to these documents:

- How to Calculate Manure Application Rates in the Pacific Northwest (PNW 0239).
- Agricultural Waste Management Field Handbook (USDA SCS 210-AWMFH 8/92).
- Integrated Animal Waste Management (C.A.S.T. Task Force Report No. 128 11/96).

Slope considerations are important when evaluating runoff potential of a site. This is especially true for irrigation application:

- As the slope of the land increases, so does erosion and runoff potential;
- Land application of wastewater through the irrigation system should be applied to match infiltration rates and crop demand.

Soil characteristics of the site should be determined:

- High permeability: Avoid soils with high permeability such as sands and gravels, rock outcrops or soils with high leaching potential;
- Low permeability: Avoid soils with greater than 50 percent clay or sodic soils because they do not provide sufficient infiltration;
- Soil texture: Light-textured soils decompose organic matter faster than heavy-textured soils. Heavy-textured soils retain more nutrients in the upper layers;
- Depth of soil. Very shallow soil or rock outcrops are not acceptable land application sites. Any applications in these areas will require regulatory authorization on a site specific basis.
- Distance to surface water should be maintained to prevent potential pollution. A vegetated buffer area is recommended at the lower end of the slopes adjacent to waterways or drainage ways which lead into streams or wells. Manure should not be applied on the buffer area. A vegetated strip will reduce the potential of suspended nutrients entering surface water.

Depth to ground water must be determined for the potential of ground water contamination. The closer ground water is to the surface, the greater the potential for nutrient contamination. If ground water is 10 feet or less, precautions should be taken when applying animal waste. Some seasonal applications may require regulatory authorization on a site specific basis.

Timing

Set up a schedule as part of your operating plan. Consider weather conditions, nutrient uptake requirements of crops, availability of labor and equipment, field availability, and accumulation of waste. The best times for land application are usually spring, just before planting, and fall, before snow and frozen soil conditions occur:

- **Fall** - Apply manure to fields containing the greatest amount of vegetation or crop residue, and incorporate to maximize utilization of nutrients. Fall incorporation before planting winter wheat or grass hay fields is a good example;
- **Winter** - Winter application to frozen, wet or snow covered soils is not recommended. Storage facilities should be designed and maintained to eliminate the need for winter application;
- **Spring -** Apply to fields where manure will be incorporated. Stored manure should be applied and incorporated as close to planting time as possible. If manure is spread on meadows, pastures, or hayfields, the potential for nutrient runoff increases. Avoid heavy applications prior to planting salt sensitive crops (See appendix B);
- **Summer -** Where suitable cropland areas are not available, waste may be applied to meadows, small grain stubble, unused pasture areas, and corn in the early season.

Management Practices

Examples of best management practices (BMP's) for manure applications are given in Appendix A. When developing a management plan for using wastes applied to agricultural lands the following factors need to be considered:

- **Irrigation water or wastewater** should be applied at a rate and frequency determined by moisture-holding capacity of soil and crop needs. Irrigation water should be applied so crops can use it efficiently and where surface runoff and deep percolation do not occur (see Table 12);
- **Incorporation** into soil soon after application is the recommended management practice for three reasons: a) nutrient loss, especially nitrogen, is minimized. Nitrogen in the ammonia form is easily lost by volatilization; b) runoff is avoided; and c) odor is minimized;
- **Uniform coverage**, whether for solid, slurry, or liquid manure, should be planned and implemented. This is as important as the application rate;
- **Grazing** should not be permitted immediately following land application or during periods of moist or wet soil conditions to minimize soil compaction and animal health problems;
- **Rain**. Nutrient losses result from runoff due to rain shortly after application, especially if manure is not incorporated into soil. If rain is expected, wait for dry weather before land application or incorporate immediately;
- **Commercial fertilizer** should not be applied unless indicated by soil testing. Applying fertilizer at normal rates in addition to a livestock waste application can cause an economic loss for the farmer, since more nutrients are being applied than the crop can use. There is also an increased chance of runoff losses and

movement of nutrients into the soil profile below the root zone. It may also cause some nutrients to accumulate in the soil;

- **Recordkeeping** is strongly recommended for documenting land application and cropping systems.

Application Rate

Overloading a field with nutrients can harm crops, soils, water quality, waste valuable nutrients and create a health problem.

Nutrient analysis on soils, manure and wastewater should be routinely conducted. Nutrient excesses and deficiencies in soil can cause similar related problems in crops.

Crop requirements: The nutrients in manure and wastewater should be applied in amounts which can be used by the crop. A common approach to determining amount of nutrients that should be applied to the soil is to use fertilizer guides and soil analyses. Table 2 shows nutrient uptake for various crops.

Water: Water intake rates of soil need to be considered when applying liquid or slurry manure. Applying more water than soil can absorb will result in ponding, runoff, or deep percolation which must be prevented. Soil structure or tilth can be destroyed by excessive wastewater application.

Moisture content: Avoid application of manure on soils which have a moisture content greater than 75% of available soil moisture remaining. This will reduce soil compaction problems and enhance soil incorporation feasibility (see Table 12). Avoid application of wastewater on soils which have a moisture content greater than 100% of available soil moisture remaining. This will decrease the likelihood of deep percolation.

Salinity: Excess soluble salt can cause problems on some irrigated land in low rainfall areas. Waste application and soil must be managed to minimize salt accumulation or yields of salt sensitive crops may suffer. Excess salt may restrict plant growth. Where a salinity problem is likely, soil salinity should be measured prior to planting crops. Crops should be selected according to soil salinity and salt tolerance (see Appendix B).

Nitrogen: Nitrogen has the greatest pollution potential of the major nutrients in manure. It is a mobile element and limits the amount of manure that can be applied safely. Figure 10 shows a simplified nitrogen cycle as it pertains to a land-animal situation. With good management, most nitrogen in manure can be recycled through soil and plants to conserve nutrients and avoid pollution. Contact local NRCS, CES, or consultants for assistance in determining nitrogen availability and loading rates.

Phosphorus: The relatively high amount of phosphorus in relation to nitrogen in most manures may become the factor limiting application rates over time. Once the phosphorus-fixing capacity of the soil is saturated, runoff and/or leaching of phosphorus will occur, causing eutrophication in receiving waters. Sandy soils have the lowest P-fixing capacity. Phosphorus applications on soils with very high phosphorus availability (i.e. high soil test phosphorus concentrations) should not exceed the crops P requirement. The phosphorus cycle is illustrated in Figure 11.

Information on soil fertility and hydraulic properties, plus plant nutrient, moisture, and salinity limitations can be obtained from the Cooperative Extension System (CES) of the University of Idaho and from the Natural Resources Conservation Service (NRCS).

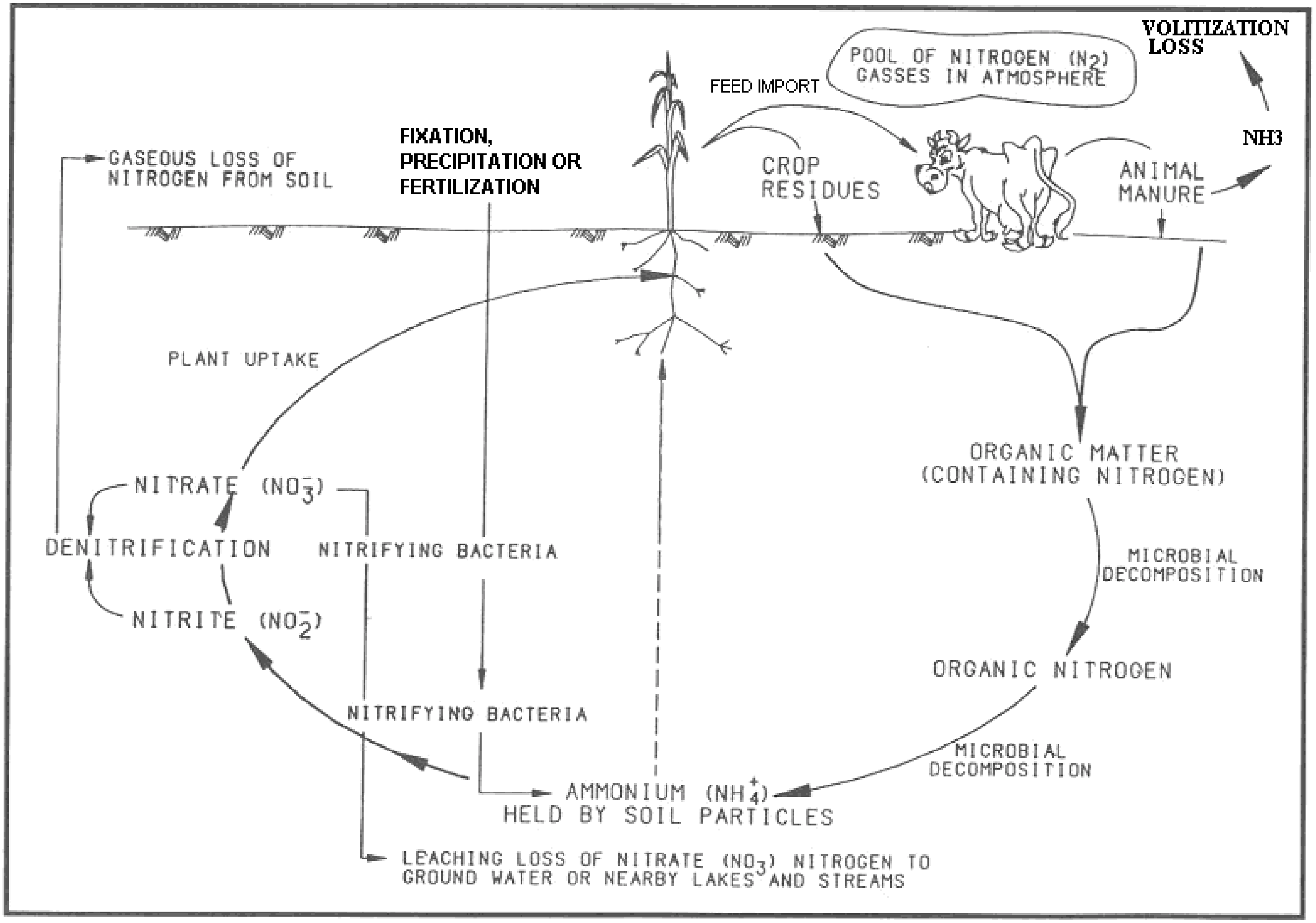


Figure 10. Simplified nitrogen cycle for an animal enterprise.

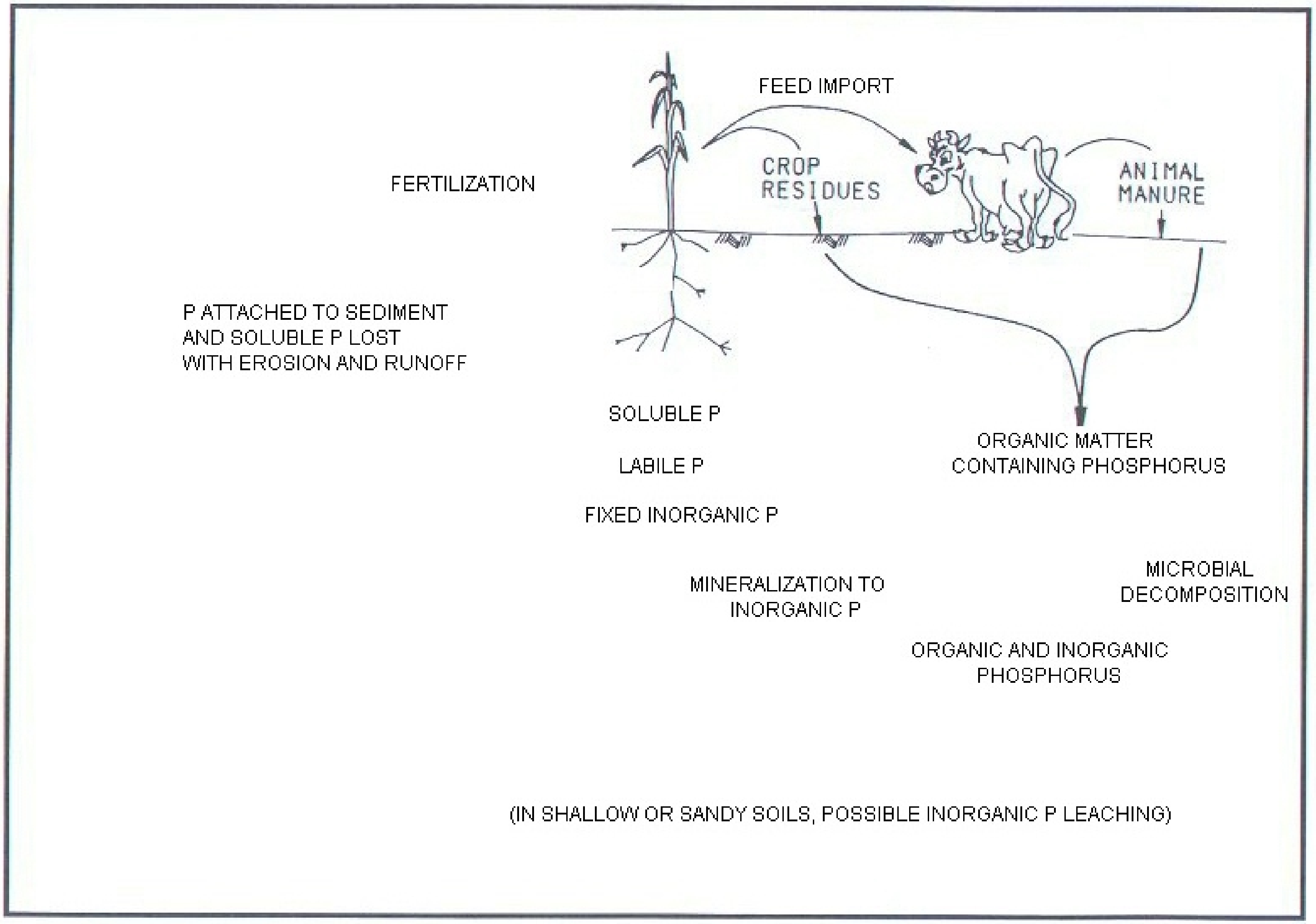


Figure 11. Simplified phosphorus cycle for an animal enterprise.

Chapter 11 Odor Control

Odor is best controlled by maintaining aerobic conditions (well-oxygenated or aerated) and to prevent anaerobic conditions (without oxygen) from developing within solid or liquid manure storage. Anaerobic decomposition typically produces objectionable odors. In liquid storage ponds greater than three feet deep, anaerobic conditions will develop, but odors can be kept to a minimum with good maintenance practices.

Conditions under which odors are produced fall into the following categories. Under each are recommendations to prevent odor-producing conditions.

Inadequate Drainage

Extended periods of standing water and excessively moist pen conditions due to inadequate drainage can cause odors:

- Follow guidelines for good site selection;
- Adequate sloping within corrals, two percent or greater, will improve drainage conditions;
- Backfill holes and low spots in the corral surface;
- Eliminate spillage and overflow from watering systems;
- Do not allow manure to block drainageways;
- Construct additional drainageways where necessary. Such drainage should be directed to waste water storage facilities.

General Housekeeping

Observe these general housekeeping measures to keep odors down:

- Feed spillage around feed bunks and feed mills can cause odors. Keep spillage to a minimum, especially under moist conditions. Bacterial decomposition of feed can produce odors similar to decomposition of manure;
- Improper carcass disposal can cause odors. Dead animals should be picked up within 24 hours after death;
- Excessive accumulation of manure in feed pens can cause odors. Clean feed pens on a regular schedule and prevent moisture increase. Frequency is dependent on moisture conditions.

Manure Storage Management

Improperly-managed manure storage facilities can cause odors:

- Clean solids, settling basins, and channels on a regular schedule. For earthen basins or channels, leave a layer of manure on the bottom to provide a barrier and prevent infiltration of liquid waste;

- If possible, schedule land application when predicted wind speeds exceed five miles per hour;
- Apply early in the day when air is warming and rising;
- Use light to moderate application rates;
- Consider using odor control chemicals in liquid storage basins before removal and disposal;
- Reducing amount of solids in storage lagoons will significantly reduce odors;
- Some innoculants may reduce odor and decrease solids.

Chapter 12 Hazardous Materials

Use of pesticides, sanitizing agents, and petroleum products in confined animal feeding operations for livestock and dairy can result in hazardous waste generation which must be handled under strict state and federal requirements. The use of good management practices and proper handling procedures by the CFO operator can significantly reduce or, in many cases, eliminate this potential problem.

Pesticides

The use of pesticides is regulated under FIFRA, the Federal Insecticide-Fungicide-Rodenticide Act, and under the Idaho Pesticide Law. In Idaho, pesticide applicator licenses are required to purchase and use restricted-use pesticides. Pesticide products have label directions for use, storage, and disposal which must be followed to prevent contamination of water, animal feeds, or other animal products. Following label directions for disposal of pesticide wastewater can prevent run-off into surface waters or impacting ground water.

Recycling or reusing these chemicals is encouraged to reduce waste production. Pesticides may be used in the treatment of livestock according to label directions. The introduction of new FDA-approved injectable products has reduced the use of pesticides in dipping vats in recent years.

The following are recommended practices for pesticide use in CFO operations:

- Keep pesticides in original containers. When mix solutions are prepared separately from original products, copies of labels should accompany them;
- Triple rinse when removing pesticides from containers to allow proper disposal. Rinse water should be added to the spray solution. Pesticide containers which have been properly rinsed are not considered hazardous waste;
- Purchase and mix only those amounts of pesticides necessary for current use, reducing storage requirements and minimizing the potential for spills or leakage;
- Store pesticides in areas away from dairy or livestock products, feeds and water sources. These areas should be dry, well-ventilated, and not subject to freezing temperatures;
- Use pesticide products only as directed on the labels. Care must be taken to ensure products are approved for livestock and dairy operations and labeled for such use;
- Maintain accurate records for tracking pesticide application.

For information regarding livestock pest control, contact your local county extension agent or the Idaho State Department of Agriculture, Division of Agricultural Resources, (208) 332-8610.

Petroleum Products

Petroleum products released from storage systems can impact water quality or human health through several modes of migration. In the environment, petroleum products can exist simultaneously as:

- Residual hydrocarbons absorbed by the soil;
- Hydrocarbons vapor free to migrate in soil pores above water table;
- Accumulated liquid hydrocarbons floating on water table;
- Hydrocarbons dissolved in ground water or surface water.

Petroleum products like gasoline are made up of more than 200 hydrocarbon components. Benzene, toluene, ethyl benzene, and xylene (BTEX) are of prime concern because of high toxicity, high volatility, and their ability to dissolve easily in water. Physical and chemical characteristics of BTEX allow them to dissolve and migrate readily with ground water, creating the potential to impact domestic water supplies.

Other potential hazardous waste which may result from CFO operations includes sanitizing agents, acid washes, and petroleum products. These should be handled to prevent run-off into surface waters or ground water contamination. Handling hazardous waste is regulated under federal and state requirements including the Federal Resource Conservation Recovery Act (RCRA) and the Idaho Hazardous Material Management Act (HWMA). Questions regarding hazardous waste disposal in Idaho should be directed to the Idaho Department of Health and Welfare, Division of Environmental Quality, Permits & Enforcement (RCRA Enforcement Bureau), 1410 N. Hilton, Boise, ID 83706, (208) 373-0502.

Underground Storage Tanks

In 1988, the U.S. Environmental Protection Agency (EPA) released regulations governing use of underground storage tanks (UST) containing petroleum products and other hazardous chemicals. Federal UST regulations include provisions for leak detection corrosion protection, spill and overfill prevention, and financial responsibility (leak insurance). Certain classes of UST's are exempt or deferred from regulation, including those used for farm or residential purposes with a capacity of 1100 gallons or less.

However, persons responsible for any petroleum handling activity resulting in leaks or spills are accountable for cleanup under state regulation, regardless of federal exemption. Accidental surface spills of petroleum hydrocarbon products are most commonly associated with the transportation and delivery of fuel to retail facilities. Idaho Release, Reporting and Corrective Action Regulations [IDAPA 16.01.02.851 and .852], require notification within 24 hours of any spill of petroleum product greater than 25 gallons. Cleanup of petroleum releases from any source, including UST's, is enforced through The Idaho Water Quality Standards and Wastewater Treatment Requirements, Section 2850. DEQ is the lead agency responsible for enforcing and overseeing cleanup of petroleum contamination in Idaho. They may be contacted at (208) 373-0502.

Tables

Table 2. Nutrient uptakes for various crops

Crop	Yield	N lb/acre	P_2O_5 lb/acre	K_2O lb/acre
Corn	150 bu	200	80	215
Corn	180 bu	240	100	240
Corn Silage	32 tons	250	105	250
Potatoes	500 cwt	270	100	550
Wheat	100 bu	175	70	200
Oats	100 bu	115	40	145
Barley	100 bu	150	55	150
Alfalfa	8 tons	480	95	480
Grasses-orchard, brome, etc	5 tons	220	65	315
Sugar Beets	30 tons	255	60	550

Source: Western Fertilizer Handbook, 1985.

To determine application on specific crops, see University of Idaho, College of Agriculture Fertilizer Guides.

Table 3. Waste produced daily by 1,000-pound cow and where it is deposited.

Area	Percent	Cubic Feet
Housing Area	40	.548
Feeding Area	45	.617
Holding Pen	10	.137
Milk Parlor	5	.068

Total cubic feet/1,000-pound cow – 1.370

Table 4. Volume of milkhouse and parlor wastes.

Washing Operation	Water Volume
Bulk Tank Automatic Wash Manual Wash	 50 to 60 gal/wash 30 to 40 gal/wash
Pipeline In parlor (Volume is higher for long stanchion barns)	75 to 125 gal/wash
Pail Milkers	30 to 40 gal/wash
Misc. Equipment	30 gal/day
Cow Prep Wash Automatic Manual Parlor Floor Milkhouse Floor Holding Pen (Sprinklers)	 1 to 4.5 gal/wash/cow .25 to .5 gal/wash/cow 40 to 75 gal/day 10 to 20 gal/day 5 gal/min/head (dependent on size, pressure, etc.)

Table 5. Bedding requirements for dairy cattle.

Housing System	**Type of Bedding**		
	Long Straw	**Chopped Straw**	**Shavings**
	(lb. Bedding/day/1,000 lb. Cow weight		
Stanchion Barn	5.4 lb – 0.6cu ft	5.7 lb – 0.4 cu ft	6.5 lb – 0.35 cu ft
Free Stall Barn	2.6 lb – 0.3 cu ft	2.7 lb – 0.2 cu ft	3.1 lb – 0.15 cu ft
Loose Housing	9.3 lb – 1.05 cu ft	11.0 lb – 0.8 cu ft	12.6 lb – 0.7 cu ft

* Note cubic feet values are the reduced volume after compaction. The actual volume of bedding used is twice the value shown.

Table 6. Storage requirements due to runoff on paved or frozen lots.

Rainfall In inches 25 yr/24 hr	Paved, Frozen, or Steep Lots (100% Runoff)		Unpaved Lots	
	Runoff Inches	Cu ft/1000 sq ft	Runoff Inches	Cu ft/1000 sq ft
1.0	1.0	83.33	0.359	29.91
1.1	1.1	91.66	0.430	35.83
1.2	1.2	100.00	0.504	42.01
1.3	1.3	108.33	0.580	48.37
1.4	1.4	116.66	0.659	54.93
1.5	1.5	125.00	0.740	61.84
1.6	1.6	133.33	0.823	68.48
1.7	1.7	141.66	0.905	75.43
1.8	1.8	150.00	0.990	82.5
1.9	1.9	158.33	1.076	89.66
2.0	2.0	166.66	1.163	96.92
2.1	2.1	175.00	1.251	104.24
2.2	2.2	183.33	1.340	111.63
2.3	2.3	191.66	1.429	119.07
2.4	2.4	200.00	1.519	126.58
2.5	2.5	208.33	1.610	134.13
2.6	2.6	216.66	1.701	141.73
2.7	2.7	225.00	1.793	149.38
2.8	2.8	233.33	1.885	157.07
2.9	2.9	241.66	1.977	164.78
3.0	3.0	250.00	2.071	172.54

* Soil Conservation Service runoff curve number value of 91 was used.

$$\text{SCS Equation : } Q = \frac{(P - 0.2\,S)^2}{P + 0.8\,S}$$

Where Q = runoff (inches), P = rainfall (inches), and S = maximum potential difference between rainfall and runoff.

$$S = (1000/N) - 10$$

Where N = an empirical number characterizing the runoff-producing surface. A surface with an N value of 100 would have no surface storage, and all water would run off. An N value of 91 is recommended by SCS for earth lots. The N value is sometimes call the "runoff curve number."

Storage capacity for three inches of snowmelt runoff must be provided, or use the one-in-five year runoff value of winter precipitation accumulation for your area (see Table 6). The N value of 91 for a 24-hour storm converted to a 30-day N value equals 76.

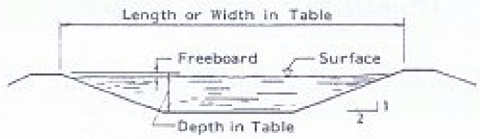
Table 7. The 1-in-5 year (20 percent chance) precipitation and runoff values*

Station	Total Precipitation	Total Runoff	Cubic ft/1000 sq ft
Bliss 4NW	6.0	1.3	108
Boise Lucky Peak Dam	8.1	2.1	175
Boise WSO, Airport	6.6	1.4	117
Bonners Ferry 1SW	12.7	5.1	425
Burley Airport	4.8	0.8	67
Cabinet Gorge	17.3	8.3	692
Caldwell	6.1	1.2	100
Cambridge	12.6	5.1	425
Cascade 1NW	12.9	5.2	433
Castleford 2N	5.8	1.3	108
Challis	2.4	0.1	8
Coeur d'Alene R.S.	14.3	6.2	517
Council	16.6	8.1	675
Deer Flat Dam	5.2	0.8	67
Driggs	6.9	1.4	117
Emmett 2E	7.3	1.7	142
Fairfield R.S.	10.6	3.9	325
Garden Valley R.S.	14.6	6.8	567
Glenns Ferry	5.8	1.3	108
Gooding 2S	5.6	0.9	75
Grace	6.0	1.1	92
Grandview 2W	3.5	0.3	25
Grangeville	8.5	2.2	183
Hailey 3NNW	9.9	3.6	300
Hazelton	5.6	1.0	83
Hill City 1W	9.8	3.4	283
Hollister	4.2	0.5	42
Idaho Falls 16E	5.8	0.7	58
Idaho Falls WSFO Airport	4.8	0.6	50
Jerome	5.6	1.0	83
Kamiah	9.9	3.0	250
Kellogg	15.8	7.2	600
Kuna 2NNE	5.4	0.9	75
Lewiston WSO Airport	5.5	0.8	67
Mackay R.S.	3.8	0.4	33
Malta 2E	4.2	0.6	50
McCall	15.9	7.4	617
Minidoka Dam	4.5	0.6	50

Station	Total Precipitation	Total Runoff	Cubic ft/1000 sq ft
Montpelier R.S.	6.2	1.1	92
Mountain Home	5.9	1.2	100
New Meadows R.S.	13.8	5.8	483
Oakley	3.9	0.4	33
Ola 4S	12.8	5.2	433
Parma Experimental Station	5.9	1.0	83
Paul 1ENE	4.7	0.8	67
Payette	6.9	1.5	125
Picabo	8.1	2.3	192
Pocatello Airport	6.0	1.0	83
Porthill	9.6	3.1	258
Preston KACH	7.6	1.8	150
Priest River Experimental Station	17.1	8.1	675
Richfield	6.5	1.5	125
Rupert 3WSW	5.0	0.7	58
St. Anthony 1WNW	6.2	1.1	92
Salmon KSRA	3.5	0.3	25
Sandpoint KSPT	18.2	9.0	750
Shoshone 1WNW	6.2	1.4	117
Sugar City	5.0	0.6	50
Twin Falls 3SE	4.7	0.8	67
Twin Falls WSO Airport	5.3	1.0	83
Weiser 2SE	7.1	1.7	142

* - The period covered in this table is the accumulated months of December, January, February, and March. The runoff was computed using a 24-hour Runoff Curve Number of 91 for unpaved lots and converted to the 30-day Runoff Curve Number value of 76.

Table 8. Earth basin, holding pond, and lagoon capacities. Bank slope = 2:1 Volume allows for two feet of freeboard. All dimensions are in feet



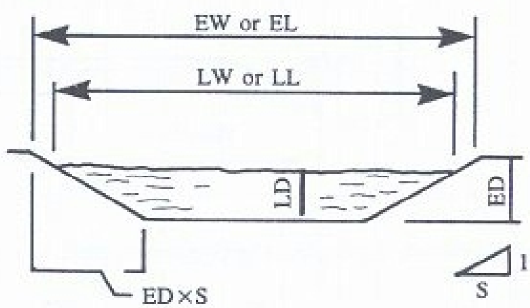
Volume, thousands of ft³	Depth 8, Interior width 50	75	100	150	200	Depth 10, Interior width 50	75	100	150	200	Depth 12, Interior width 50	75	100	150	200	Depth 15, Interior width 50	75	100	150	200
	Interior length, ft																			
4	41	31	-	-	-	40	32	-	-	-	40	34	-	-	-	39	-	-	-	-
6	52	37	32	-	-	50	37	-	-	-	49	38	-	-	-	49	40	-	-	-
8	63	43	36	-	-	59	42	-	-	-	58	42	37	-	-	58	44	-	-	-
10	74	49	40	-	-	69	47	-	-	-	67	46	40	-	-	68	47	42	-	-
15	102	65	51	-	-	93	59	48	-	-	90	57	47	-	-	92	57	48	-	-
20	130	80	61	45	-	117	71	56	-	-	113	68	54	-	-	116	66	54	-	-
30	185	110	82	58	-	165	96	72	-	-	158	89	68	51	-	164	85	66	52	-
40	241	140	103	71	-	213	120	89	63	-	204	110	82	60	-	212	104	77	59	-
50	296	171	124	84	66	261	145	105	73	-	249	132	96	68	-	260	122	89	65	-
60	352	201	144	97	75	309	169	122	83	66	295	153	109	76	62	308	141	101	72	-
70	407	231	165	109	85	357	194	138	93	73	340	174	123	84	68	356	160	112	78	65
80	463	262	186	122	94	405	218	154	103	80	386	195	137	92	74	405	179	124	85	70
90	518	292	207	135	103	453	243	171	113	87	431	217	151	101	80	453	197	135	92	74
100	574	322	228	148	112	501	267	187	123	95	476	238	165	109	85	501	216	147	98	79
110	630	352	249	161	122	550	292	204	132	102	522	259	179	117	91	549	235	159	105	84
120	685	383	269	173	131	598	316	220	142	109	567	280	193	125	97	597	254	170	112	88
130	741	413	290	186	140	646	341	237	152	116	613	302	207	133	103	645	272	182	118	93
140	796	443	311	199	149	694	365	253	162	123	658	323	221	142	109	693	291	194	125	98
150	852	474	332	212	159	742	390	270	172	130	704	344	234	150	114	741	310	205	132	102
160	907	504	353	225	168	790	414	286	182	137	749	366	248	158	120	789	329	217	138	107
170	-	534	374	238	177	838	439	302	192	144	795	387	262	166	126	837	347	229	145	111
180	-	565	394	250	186	886	464	319	202	151	840	408	276	174	132	885	366	240	151	116
190	-	595	415	263	196	934	488	335	212	158	886	429	290	183	138	933	385	252	158	121
200	-	625	436	276	205	982	513	352	222	166	931	451	304	191	144	981	404	264	165	125
225	-	701	488	308	228	-	574	393	247	183	-	504	339	211	158	-	451	293	181	137
250	-	777	540	340	251	-	635	434	271	201	-	557	373	232	173	-	498	322	198	148
275	-	852	592	372	274	-	696	475	296	219	-	610	408	252	187	-	544	351	214	160

Volume, thousands of ft³	Depth 10, Interior width 100	150	200	300	400	Depth 15, Interior width 100	150	200	300	400	Depth 20, Interior width 100	150	200	300	400	Depth 25, Interior width 100	150	200	300	400
	Interior length, ft																			
300	516	321	237	160	124	380	231	172	120	-	334	197	148	-	-	322	183	139	-	-
325	557	346	254	171	132	409	248	183	127	-	359	210	157	113	-	346	194	146	109	-
350	599	371	272	182	140	439	264	195	134	-	384	223	166	118	-	369	205	153	113	-
375	640	395	290	194	148	468	281	206	142	112	408	236	175	124	-	393	216	161	117	-
400	681	420	308	205	157	497	297	218	149	117	433	250	184	129	105	417	228	168	122	-
425	722	445	325	216	165	526	314	230	156	123	458	263	193	135	109	440	239	176	126	105
450	763	470	343	227	173	555	330	241	163	128	483	276	201	140	113	464	250	183	131	109
475	804	495	361	239	182	584	347	253	171	133	508	289	210	145	117	488	262	191	135	112
500	845	519	379	250	190	613	364	264	178	138	532	302	219	151	121	511	273	198	140	115
600	1010	619	450	295	223	730	430	311	207	159	632	354	255	173	136	606	318	228	157	127
700	-	718	521	341	256	846	496	357	236	181	731	407	291	194	152	700	364	258	175	140
800	-	817	592	386	290	963	563	403	265	202	830	459	326	216	168	795	409	287	193	152
900	-	916	663	431	323	1080	629	450	293	223	929	512	362	238	183	889	454	317	210	165
1000	-	1015	734	477	356	-	695	496	322	244	1028	564	397	259	199	984	500	347	228	178

Table 9. Conversion Factors. Multiply to the right (cu ft x 7.5 gal). Divide to the left (gal/7.5 = cu ft)

Cubic feet	7.5	gallons	Acre-inch	27,154	gallons
	1,728	cubic inches		3,621	cubic feet
	62.4	pounds water		133	tons
Gallons	231	cubic inches	Acre-foot	325,848	gallons
	0.134	cubic feet		43,560	cubic feet
	8.3	pounds water	Acre-in/hr	450	gpm
Cubic yards	27	cubic feet		1	cfs (approx.)
Acres	43,560	square feet	psi	2.31	feet of water head
	4,840	square yards	cfs	448.8	gpm
Miles	5,280	feet		646,317	gal/day
	1,760	yards	ppm or mg/1	0.0001	percent

Unit Abbreviations
cfm = cubic feet per minute
cfs = cubic feet per second
cfh = cubic feet per hour
psi = pounds per square inch
gpm = gallons per minute
fps = feet per second
ppm = parts per million



$LW = EW - 2 \times FB \times S$
$LL = EL - 2 \times FB \times S$
$LD = ED - FB$

Unit Abbreviations:
LW = liquid width, ft
EW = earth basin width, ft
FB = freeboard, ft
S = sideslope, ft
= amount of run for 1 foot fall
LL = liquid length, ft
EL = earth basin length, ft
LD = liquid depth, ft
ED = earth basin depth, ft

$$V = (LW \times LL \times LD) - [(S \times LD^2) \times (LW + LL)] + (4 \times S^2 \times LD^3 \div 3)$$

V = liquid volume, ft³

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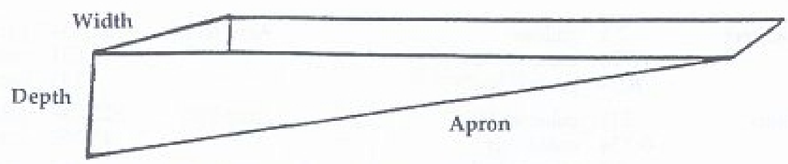
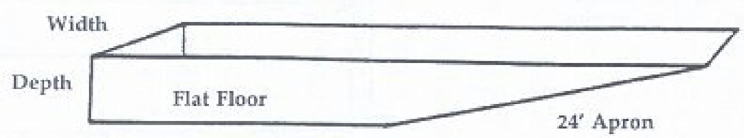
Table 10. Gravity separator volumes.



Volumes of Gravity Separators of Varying Depths, Width and Lengths with Single Slope Apron Floor

Apron Length	40			50			60			70			80		
Width	10	12	14	10	12	14	10	12	14	10	12	14	10	12	14
Depth															
3	500	696	812	625	750	875	750	900	1050	875	1050	1225	1000	1200	1400
4	700	974	1137	875	1050	1225	1050	1260	1470	1225	1470	1715	1400	1680	1960
5	900	1253	1462	1125	1350	1575	1350	1620	1890	1575	1890	2205	1800	2160	2520
6	1100	1531	1786	1375	1650	1925	1650	1980	2310	1925	2310	2695	2200	2640	3080
7	1300	1810	2111	1625	1950	2275	1950	2340	2730	2275	2730	3185	2600	3120	3640
8	1500	2088	2436	1875	2250	2625	2250	2700	3150	2625	3150	3675	3000	3600	4200



Volumes of Gravity Separators of Varying Depths, Width and Lengths with Combination Apron and Flat Floor

Flat Floor Length Plus 24 Foot Apron	40			50			60			70			80		
Width	10	12	14	10	12	14	10	12	14	10	12	14	10	12	14
Depth															
3	1300	1560	1820	1550	1860	2170	1800	2160	2520	2050	2460	2870	2300	2760	3220
4	1820	2184	2548	2170	2604	3038	2520	3024	3528	2870	3444	4018	3220	3864	4508
5	2340	2808	3276	2790	3348	3906	3240	3888	4536	3690	4428	5166	4140	4968	5796
6	2860	3432	4004	3410	4092	4774	3960	4752	5544	4510	5412	6314	5060	6072	7084
7	3380	4056	4732	4030	4836	5642	4680	5616	6552	5330	6396	7462	5980	7176	8372
8	3900	4680	5460	4650	5580	6510	5400	6480	7560	6150	7380	8610	6900	8280	9660

* note - all depths are actual with 6 inches freeboard allowed

Table 12. Moisture Application Guide

Available Soil Moisture	Loamy Sand	Sandy Loam	Loam/Silt Loam	Clay Loam
0 - 25 Percent	Dry, Loose, Single-Grained; flows through fingers	Dry, Loose; Flows through fingers	Powdery dry, sometimes slightly crusted, but easily broken down into powdery condition	Hard, Baked, Cracked; Sometimes has loose crumbs on surface
25-50 Percent	Appears to be dry; Will not form a ball with pressure[1]	Appears to be dry; Will not form a ball[1]	Somewhat crumbly, but holds together with pressure	Somewhat pliable; will ball under pressure[1]
50-75 Percent	Appears to be dry; will not form a ball with pressure	Tends to ball under pressure, but seldom holds together	Forms a ball somewhat plastic; will sometimes slick slightly with pressure	Forms a ball; ribbons out between thumb and forefinger
75-100 Percent	Tends to stick together slightly; sometimes forms a very weak ball under pressure	Forms weak ball, Breaks easily; will not stick	Forms a ball, is very pliable; slicks readily, if relatively high in clay	Easily ribbons out between fingers; has slick feeling
100 Percent	Upon squeezing, no free water appears on soil, but wet outline of ball is left on hand	Upon squeezing, no free water appears on soil; but wet outline of ball is left on hand	Upon squeezing, no free water appears on soil, but wet outline of ball is left on hand	Upon squeezing, no free water appears on soil; but wet outline of ball is left on hand

1. Ball is formed by squeezing a handful of soil very firmly

Description of Method: The best way to determine how much water to apply is to measure the amount of moisture in the soil and amount the soil will hold at field capacity. However, this is time-consuming and requires special equipment not commonly owned by irrigators.

A common method is feel and appearance, where the amount of moisture present is estimated. When the field capacity of the soil is known, the amount of moisture needed is then easy to calculate.

Although gauging moisture conditions by feel and appearance is not the most accurate method, with experience and judgement the irrigator should be able to estimate the moisture level within 10 to 15 percent.

Example: Assume a silt loam soil is to be irrigated. Samples are taken at six-inch, 18-inch, and 36-inch depths. Select the portion of the page showing medium texture soils and assume moisture conditions closely resemble 25 to 50 percent for the six-inch depth, 50 to 75 percent for 18, and 75 to 100 percent for 36. The percent available would be 25, 50, and 75. From the moisture deficiency table, the top foot would need 1.5 inches, the second foot one inch, and the third and fourth feet 0.5 inch per foot, or a total of 3.5 inches for the four-foot zone.

Obtaining Samples: For row crops, measurements should be made in the soil from which plant roots extract their moisture and according to the moisture-extraction pattern of the particular crop. One measurement should be made in the upper quarter of the root zone and one or two more measurements at lower levels. If the maximum moisture-extraction depth for a given crop is 48 inches, for example, measurements probably should be made at about six, 18, and 36 inches. To predict when to irrigate during early stages of root development, the six-inch measurement is all that is needed for most crops.

Waste Management Checklist

Have you reviewed current state regulations? (Chapter 2)	
Are you required to comply with NPDES? (Chapter 2)	
Do county regulations impact you? (Contact your local planning and zoning office)	
Do you know where to get help? (Chapter 3)	
Have you reviewed information about planning a waste system? (Chapters 4-7)	
If you have selected a type of system, are you aware of specific design criteria? (Chapter 8)	
Have you completed storage worksheets accurately? (Chapter 9)	
Have you considered a method of utilizing liquid and solid waste? (Chapter 10)	
Are you concerned about odor control or hazardous waste? (Chapters 11 and 12)	
Have you filed your intent to comply with NPDES? (Chapter 2)	
Have you developed an operating plan? (Chapter 3)	

Glossary

Acronyms

ICA	Idaho Cattle Association
IDA	Idaho Dairymen's Association
CAFO	Confined Animal Feeding Operation
CFO	Confined Feeding Operation
NRCS	Natural Resources Conservation Service
ASCS	Agricultural Stabilization and Conservation Service
DEQ	Division of Environmental Quality
SCD	Soil Conservation District
BMP	Best Management Practice
EPA	Environmental Protection Agency
ISDA	Idaho State Department of Agriculture
CES	Cooperative Extension System

Terms

Aerobic

Having or occurring in the presence of free oxygen.

Agricultural waste management system

A combination of conservation practices and management that, when installed or applied, will protect the resource base.

Agricultural wastes

Wastes normally associated with the production and processing of food and fiber on farms, feedlots, ranches, ranges and forests which may include animal manure, crop residues, and dead animals; also, agricultural chemicals, fertilizers, and pesticides which may find their way into surface and subsurface water.

Anaerobic

The absence of molecular oxygen, or growing in the absence of oxygen.

Best Management Practice

A practice or combination of practices found to be the most effective, practicable (including economic and institutional considerations) means of preventing or reducing the amount of pollution generated by non-point sources to a level compatible with water quality goals.

Chemical Oxygen Demand

COD is a measure of the soil oxygen required to decompose easily decomposable organic matter added to warm moist soils. Addition of excess decomposable materials (COD) followed by irrigation can cause crop damage or death.

Clay

Soil that is 40 percent or more clay, less than 45 percent sand, and less than 40 per cent silt.

Confined Feeding Operation

A contiguous area or parcel of land upon which there are confined livestock including fowl, furbearers, cattle, dairy animals, swine, sheep, goats, horses, llamas, mules, donkeys, and similar domesticated animals including their offspring.

Contamination

Degradation of natural water quality as a result of man's activities. No specific limits are implicated because of the degree of permissible contamination depends upon the intended end use or uses of the water.

Cost effectiveness

A term used to economically compare agricultural non-point source control alternatives. It is generally expressed as dollars per unit pollutant load reduction.

Eutrophication

A natural or artificial process of nutrient enrichment whereby a water body becomes abundant in aquatic plants and low in oxygen content.

Evapotranspiration

The loss of water from an area by evaporation from the soil or snow cover and transpiration by plants.

Exchangeable Sodium Percentage

ESP is the ration of exchangeable sodium to the total cation exchange capacity in the soil. It is calculated as:

ESP = (exchangeable sodium/cation exchange capacity) * 100

It is undesirable for this value to be greater than 10 from an infiltration standpoint.

Field moisture capacity

The moisture content of a soil, expressed as a percentage of the oven-dry weight, after the gravitational, or free, water has drained away.

Grass infiltration area

An area with vegetative cover where runoff water infiltrates into the soil.

Ground water

Water filling all unblocked pores of underlying material below the water table.

Ground water table

The surface between the zone of saturation and the zone of aeration; the surface of an unconfined aquifer.

Hydrologic condition
: Description of the moisture present in a soil by amount, location, and configuration.

Land application
: Application of manure, sewage sludge, municipal wastewater, and industrial wastes to land for reuse of the nutrients and organic matter for their fertilizer value.

Liquid manure
: A mixture of water and manure than can be pumped, generally less than 10 percent solids.

Livestock Confinement
: The keeping of animals within a structure or area for a period of more than 48 hours during any seven consecutive days, except where such livestock are fed exclusively on growing range, pasturage or crop residues, or are confined on cropland of 20 or more acres for a period of not more than 120 days in any calendar year.

Livestock wastes
: A term sometimes applied to manure that may also contain bedding, spilled feed, water, or soil. It also includes wastes not particularly associated with manure, such as milking center or washing wastes, and milk, hair, feathers, or other debris.

Manure
: The fecal and urinary excretions of livestock and poultry.

Mechanical solids separation
: The process of separating suspended solids from a liquid-carrying medium by trapping the particles on a mechanical screen or sieve or by centrifugation.

Non-point source
: Entry of effluent into a water body in a diffuse manner so there is no definite point of entry.

Nutrients
: Elements required for plant or animal growth, including the macronutrients (nitrogen, phosphorus, and potassium), which are the major nutrients required and micronutrients, which include a number of other elements that are essential but needed in lesser amounts.

Phosphate
: A salt or phosphoric acid, such as calcium phosphate rock.

Phosphorus

One of the primary nutrients required for the growth of plants. Phosphorus is often the limiting nutrient for the growth of aquatic plants and algae.

Point source

The release of a contaminant or pollutant, often in concentrated form, from a conveyance system, such as a pipe, into a water body.

Pollution

The presence in a body of water or soil or air of a substance (contaminant) in such quantities that it impairs the body's usefulness or renders it offensive to the senses of sight, taste, or smell. In general, a public health hazard may be created, but in some instances only economic or aesthetics are involved, such as when foul odors pollute the air.

Root zone

The part of the soil that can be penetrated by plant roots.

Runoff

The part of precipitation or irrigation water that appears in surface streams or water bodies; expressed as volume (acre-inches) or rate of flow (gallons per minute, cubic feet per second).

Sewage sludge

Settled sewage solids combined with varying amounts of water and dissolved materials that are removed from sewage by screening, sedimentation, chemical precipitation, or bacterial digestion.

Slope

The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. A slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Sodium Adsorption Ratio

SAR. A simple method of estimating Soil ESP or the Soil ESP that will develop by irrigating with water of a given SAR. Calculate as SAR= $Na/[(Ca + Mg)/2]^{1/2}$ when Na, Ca, and Mg units are me/l. If data is in ppm, then data must be converted to me/l. It is undesirable for this value to be greater than 10 from an infiltration standpoint.

Solid manure storage

A storage unit in which accumulations of bedded manure or solid manure are stacked before subsequent handling and field spreading. The liquid part, including urine and precipitation, may or may not be drained from the unit.

Volatilization
: The loss of gaseous components, such as ammonium nitrogen, from animal manure.

Waste storage pond
: An impoundment made by excavation or earthfill for temporary storage of animal or other agricultural waste.

Waste treatment lagoon
: An impoundment made by excavation or earthfill for biological treatment of animal or other agricultural wastes. Lagoons can be aerobic, anaerobic, or facultative, depending on their loading and design.

Waste management system
: A planned system in which the available water supply is effectively used by managing and controlling the moisture environment of crops to promote the desired crop response, to minimize soil erosion and loss of plant nutrients, to control undesirable water loss, and to protect water quality.

Water quality
: The excellence of water in comparison with its intended use or uses.

Water table
: The surface between the vadose zone and the ground water; that surface of a body of unconfined ground water at which the pressure is equal to that of the atmosphere.

Guidance Manuals

1.A Cattleman's Reference Guide for Water Quality
Jim Clawson, University of California, Davis
National Cattlemen's Association
attn: Greg Ruehle, Manager, Environmental Issues
1301 Pennsylvania Avenue NW, Suite 300
Washington, DC 20004
(202)347-0228; FAX (202)638-0607

2.Livestock Waste Facility Handbook, 3rd Edition, 1993
Midwest Plans Service
Iowa State University
122 Davidson Hall
Ames IA 50011
(800)562-3618; (515)294-4337

3.Agricultural Waste Management Field Manual, 1992
USDA Natural Resources Conservation Service
(Available at your local NRCS field office)

4.Environmental Protection Technology Series, 1975
Treatment and Ultimate Disposal off Cattle Feedlot Wastes
Survival of Pathogens in Animal Manure Disposal
Research Status on Effects of Land Application of Animal Wastes
Pollution Abatement from Cattle Feedlots in Northeastern Colorado and Nebraska
National Environmental Research Center
Office of Research and Development
U.S. Environmental Protection Agency
Corvallis, OR 97330
(503)754-4507

5.A Guide to Planning Livestock Pollution Control Systems, 1972
Roy Taylor, Extension Agricultural Engineer
Ag Engineering Office Building
University of Idaho
Moscow, ID 83843
(208)885-7626; FAX (208)885-7908
(Ask for the accompanying "Data Sheet for Planning a Livestock Pollution Control System")

6.How to Calculate Manure Application Rates in the Pacific Northwest (PNW0239)
Cooperative Extension Service
University of Idaho
College of Agriculture
attn: Connie King
Moscow, ID 83843
(208)885-7982

7.Dairy Waste Management, Bulletin #694, System Planning -- Estimating Storage
Dean E. Falk and Robert M. Ohlensehlen
Cooperative Extension Service
University of Idaho
College of Agriculture
attn: Connie King
Moscow, ID 83843
(208)885-7982

8.On-Farm Composting Handbook
Northeast Regional Agricultural Engineering Service
152 Riley-Robb Hall
Cooperative Extension
Ithaca, NY 14853-5701
(607)255-7654

APPENDIX A

Best Management Practices for Manure Applications

Adapted from *Integrated Animal Waste Management*, CAST Report No. 128, 1996.

NUTRIENT MANAGEMENT RECOMMENDATIONS

1. Total nutrient applications should be based on accepted soil test results and fertilizer guides rather than on traditional crop requirement rates. The regulatory agency may require soil testing to determine appropriate application rates.
2. Decrease the nutrients from commercial fertilizer by the corresponding amount of available nutrients in the manure applied to the field..
3. Keep a record of manure and chemical fertilizer applications, crop information, and soil and manure test results on each field.
4. Test the surface soil (12 inches) in each new field for phosphorus, potassium and other nutrients, pH, EC, and cation exchange capacity; thereafter, do a routine soil test prior to manure or fertilizer application for crop production. In addition, the soil profile in each new field should be tested for nitrate-nitrogen and phosphorus to five feet. Follow a soil testing program recommended by the Cooperative Extension System or a crop consultant. The cation exchange capacity test is not needed after the initial sampling.
5. Test the waste (manure, compost or lagoon effluent) prior to application for total nitrogen, NH_4-N, phosphorus, potassium and dry matter each time the animal ration, manure storage or handling procedures are changed.
6. Apply manure uniformly with calibrated equipment. Check equipment routinely.
7. Use the nutrients carried in runoff effluent from feedlots, animal exercise or handling areas, etc. Provide a settling basin (storage lagoon) to decrease the suspended solids and nutrients before application. Construct the runoff containment facility so runoff cannot leave the property.
8. Nitrification inhibitors in liquid-manure injection systems can decrease nitrogen losses in coarse textured soils all year, in all soils during fall and summer, and in fine or medium textured soils with high water-tables during winter and spring. Volatilization losses of nitrogen will still occur if the materials are not incorporated in a timely manner.
9. To benefit crops in terms of economics and efficiency, apply the manure material at a rate to meet the crop’s Nitrogen requirement until the soil test phosphorus concentration (surface 12 inches) reaches 100 ppm, thereafter apply the material to meet the crop’s phosphorus requirements. On lighter textured soils, apply manure phosphorus to meet the crop requirement when the soil test phosphorus concentration reaches 50 ppm in the second 12 inches. The NRCS Phosphorus Availability Index can also be used to further evaluate potential phosphorus applications.
10. To prevent excessive phosphorus and potassium buildup, rotate the manure applications to as many fields as possible, or decrease applications to supply the most limiting nutrient requirement and then supplement with commercial fertilizer or some other available nutrient source.
11. Incorporate applied manures into the soil to decrease nutrient losses from runoff and volatilization within 24 hours after application. Materials should not be applied to frozen soils unless runoff is prevented.
12. Do not apply any commercial fertilizer if the soil test concentrations exceed the University of Idaho Fertilizer Guide for the crop.

CROP RECOMMENDATIONS

1. Base crop nutrient needs on realistic yield goals. Deduct nitrogen credits of last year's legumes from this year's nitrogen requirement. For the current crop year, estimate nitrogen contributions from manure, legumes, organic matter and plant residues, and irrigation water before deciding on fertilizer needs.
2. Consider using nitrogen-enriched manure to balance crop nitrogen, phosphorus, and potassium needs.
3. Use commercial fertilizer only when manure does not meet crop nutritional needs and the preplant soil test indicates a probable nutrient deficiency.
4. Apply mineral-nitrogen so that it is available during peak crop demands. A lag time exists between application and availability for organic-nitrogen sources, since they must be mineralized to ammonium and nitrate before available for crop uptake.
5. Apply fertilizer with proper timing and placement for maximum plant utilization.
6. Add a nitrification inhibitor, e.g., *N-Serve*, to stabilize nitrogen before injecting manure on poorly drained, fine textured soils or injecting high-nitrogen manure after the cropping season.
7. Incorporate manure to decrease nitrogen loss and odor, and manure runoff with nutrients.
8. Apply manure on non-legume crops as a first priority. Do not apply high COD (~40,000 ppm) liquids during hot weather on sensitive crops such as potatoes, peas, beans or alfalfa.
9. During the summer, broadcast or inject manure on pastures where nutrients can be used immediately or incorporate manure on harvested or fallow fields.
10. A crop's salinity tolerance should be considered when determining which crops will receive an application of manure.

SOIL RECOMMENDATIONS

1. Apply manure to fields with the lowest soil test nutrient concentrations.
2. To decrease compaction, runoff, denitrification, and leaching, avoid applying solid manures and lagoon effluent when soils are wet.
3. Apply manure (possibly with an inhibitor) in the fall if compaction is a prevalent soil problem.
4. To minimize nitrate leaching, apply manure to sandy soil shortly before planting time and apply small amounts of nitrogen frequently instead of a large amount at one time. Fall apply on sandy soils with an nitrification inhibitor.
5. When applying manure and wastewater to meet a particular nutrient requirement it may be necessary to supplement other nutrients with commercial fertilizer.
6. Apply manure in the fall after soil has cooled to 50 F or less, or add a nitrification inhibitor.
7. Give manure application preference to highly eroded soils with low nutrient and organic matter levels.
8 Do not apply solid manure or lagoon effluent on frozen soils unless surface runoff is prevented.
9 Minimum soil depth for potential application sites is dependent upon soil texture and depth to water table.

MANURE RECOMMENDATIONS

1. Haul the highest nutrient content manure to the farthest fields, and the lowest nutrient content to the closest fields. Inject runoff and lagoon effluent into the soil or utilize for irrigation.
2. Apply the highest nutrient manure to crops with high nutrient demands.

3. Apply the highest nutrient manure to annual legumes only if there is no better use for the nitrogen, as legumes produce their own nitrogen if none is provided.
4. To avoid leaching nitrogen to ground water, limit nitrogen applications on sandy soils, and avoid soils with high water-tables (<five feet).
5. Do not apply more potentially available nitrogen than the crop needs.
6. Apply high-phosphorus manure to fields with the lowest soil test phosphorus concentrations.

SITE AND ENVIRONMENTAL RECOMMENDATIONS

1. To minimize nitrogen loss, odor and runoff potential, inject or incorporate the same day as surface spreading.
2, Delay manure applications and tillage until spring on erosive or steep soils; and incorporate manure on non-erosive soils in the fall to retain nutrients and avoid runoff carrying nutrients.
3. Apply manure on frozen or snow covered soil only if it is necessary to empty storage, the land is not subject to flooding, the land slope is less than 2%, and the potential runoff can be retained on the property.

APPENDIX B

Relative Productivity of crops at increasing EC (mmho/cm) in the root zone

Plant Name	Scientific Names	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Alfalfa	Medicago sativa	100	100	93	85	78	71	64	56	49	42	34	27	20	12	
Apple	Malus sylvestris	100	91	75												
Barley, forage	Hordeum vulgare	100	100	100	100	100	100	93	86	79	72	65	58	51	44	37
Barley, grain	Hordeum Vulgare	100	100	100	100	100	100	100	100	95	90	85	80	75	70	65
Bean	Phaseolus Vulgaris	100	81	62	43	25	6	0								
Beet	Beta Vulgaris	100	100	100	100	91	82	73	64	55	46	38	29	20	11	2
Broccoli	Brassica Oleracea	100	100	98	89	80	71	61	52	43	34	25	16	6	0	
Cabbage	Brassica Oleracea Var. Capitata	100	98	88	79	69	59	50	40	30	20	11	1	0		
Carrot	Daucus carota	100	86	72	58	44	30	15	1	0						
Corn, forage	Zea mays	100	99	91	84	76	69	61	54	47	39	32	24	17	10	
Corn, sweet	Zea mays	100	96	84	72	60	48	36	24	12	0					
Cucumber	Cumcumis sativus	100	100	94	81	68	55	42	29	16	3	0				
Fescue	Festuca clatior	100	100	100	99	94	89	84	78	73	68	62	57	52	47	41
Grape	Vitis spp.	100	95	86	76	66	57	47	38	28	18	9	0			
Juniper	Juniperus chinensis	100	91	81	72	63	54	45	36	27	18	9	0			
Lettuce	Latuca sativa	100	91	78	65	52	39	26	13	0						
Meadow Foxtail	Alopecurus pratensis	100	95	85	76	66	56	47	37	27	17	8	0			
Muskmelon	Cucumis melo	100	100	95	80											
Onion	Allium cepa	100	87	71	55	39	23	6	0							
Orchardgrass	Dactylis glomerata	100	97	91	84	78	72	66	60	53	47	41	35	29	22	16
Pea	Pisum sativum L.	100	100	90												
Peach	Prunus persica	100	94	73	52	31	10	0								
Pear	Pyrus spp.	100	91	75												
Plum	Prunus domestica	100	91	73	55	36	18	0								
Potato	Solanum tuberosum	100	96	84	72	60	48	36	24	12	0					
Radish	Raphanus Sativus	100	90	77	64	51	38	25	12	0						
Rasberry	Rubus ideaus	100	80	62												
Rose	Rosa spp.	100	74	36	0											
Ryegrass, perennial	Lolium perenne	100	100	100	100	100	97	89	82	74	67	59	52	44	36	29
Safflower	Carthamus tinctorius	100	100	100	100	100	100	97	90	85	80	75	50			
Sorghum	Sorghum bicolor	100	100	100	100	98	90	84	78	70	63	56	50	43	36	29
Squash	Cucurbita maxima	100	100	90	74											
Strawberry	Fragaria	100	67	33	0											
Sugarbeet	Beta vulgaris	100	100	100	100	100	100	100	94	88	82	76	71	65	59	53
Tomato	Lycopersicon esculentum	100	100	95	85	75	65	55	46	36	26	16	6	0		
Trefoil, birdsfoot	Lotus corniculatus tenuifolium	100	100	100	100	100	90	80	70	60	50	40	30	20	10	0
Wheat	Tricum aestivum	100	100	100	100	100	100	93	86	79	71	64	57	50	43	36
Wheatgrass, crested	Agropyron desertorum	100	100	100	98	94	90	86	82	78	74	70	66	62	58	54
Wheatgrass, fairway	Agropyron cristatum	100	100	100	100	100	100	100	97	90	83	76	69	62	55	48
Wheatgrass, tall	Agropyron elongatum	100	100	100	100	100	100	100	98	94	89	85	81	77	73	68
Wildrye, beardless	Elymus triticoides	100	100	98	92	86	80	74	68	62	56	50	44	38	32	26

From Bresler, E., B. L. McNeal and D. L. Carter. 1982. Saline and Sodic Soils, Springer-Verlag, New York.